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BUNKER RAMO

ELECTRONIC SYSTEMS DIVISION

MEDEX PROCESSING SYSTEM

FINAL REPORT

VOLUME II: SOFTWARE

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This Summary Report
is Prepared for

Director
Acoustic Applications
Long Range Acoustic Propagation Project
Office of Naval Research
Department of the Navy

BUNKER RAMO
ELECTRONIC SYSTEMS DIVISION
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MEDEX DOCUMENTATION

INTRODUCTION

This volume contains the information necessary to understand and operate the computer programs supplied with the MEDEX PROCESSOR. The documentation is organized into three parts. The first provides a description of each of six processing options open to the user:

1. Automatic Calibration
2. Beamforming
3. Editing
4. Output of Selected Tables to Paper Tape
5. Output of the Programs to Paper Tape
6. Output of the Master Accumulator Table to Paper Tape

The first two options are of a more analytical nature and as such are discussed in greater length than the more admisistrative routines (3-6).

The documentation for individual processing options generally follows the outline:

1. Introduction - A brief description of what the routine is intended to do
2. Calling Sequence - How the routine is entered and from where
3. Description of Input
4. Description of Output
5. Errors and Restrictions
6. User Instructions
7. Description of Processing—keyed to a generalized flow diagram of the routine

The second part of the documentation is a set of detailed flow diagrams of the more analytical programs and subroutines. The more administrative type routines are basically I/O type routines with little, if any, of the mathematical foundation inherent in calibration or beam-forming. Consequently, diagrams for these, beyond the generalized level (already provided), are superfluous. This part of the documentation is contained in an Appendix.

The final part of the documentation is a complete set of profusely annotated listings, separately bound and provide with program titled index tabs.

EXECUTIVE ROUTINE

INTRODUCTION

The executive routine simply allows the user to select the type of processing he wishes to accomplish next. The user can:

1. Perform automatic calibration
2. Perform beamforming
3. Edit certain operational parameters and shading coefficients as well as display any or all of the calibration tables
4. Output tables to paper tape
5. Output programs to paper tape
6. Output master accumulator table to paper tape.

CALLING SEQUENCE

The executive is automatically entered when the system is first loaded. It is reentered each time any of the six subroutines has been completed. The user can then select another (or the same) processing mode.

DESCRIPTION OF INPUT

The only input the user enters is the numerical choice of analysis type (1 to 6).

DESCRIPTION OF OUTPUT

The only display from the routine appears as follows:

INDEX

SELECT ANALYSIS TYPE:

1. BEAMSTEER
2. AUTOMATIC CALIBRATION
3. EDIT
4. PUNCH TABLES
5. PUNCH PROGRAM
6. PUNCH MASTER ACCUMULATOR TABLE CHOICE =

ERRORS AND RESTRICTIONS

If the user enters an invalid choice, the display responds with:

NOT VALID, CHOICE =

USER INSTRUCTIONS

The selection list automatically appears on the display after the entire system has been loaded or if one of the six subroutines has returned control. The user simply enters one number corresponding to his choice of processing.

DESCRIPTION OF PROCESSING

The following flow diagram is self-explanatory.

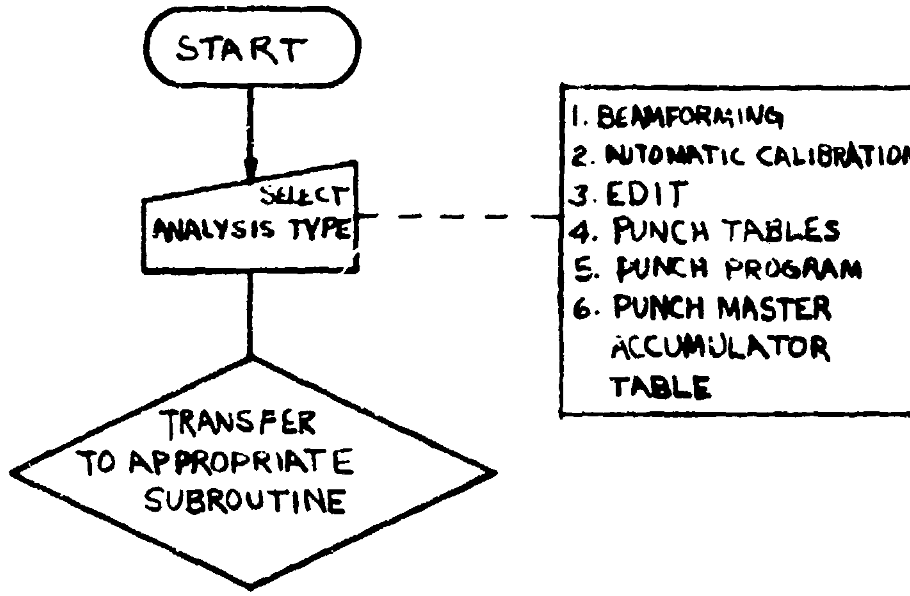

Figure 1 : EXECUTIVE

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CALIBRATION ROUTINE

INTRODUCTION

The calibration routine allows a calibration frequency to be entered into every channel. All channels are then simultaneously sampled and the resulting calculated amplitude and phase data is both displayed (and, consequently, made available for hard copy) and stored in internal files to be used in subsequent beamforming analyses.

This routine is also used in dockside checkout to verify that all system interconnections are proper and give expected amplitude response, phase response linearity, and noise measurements for the entire system signal path, extending from the preamplifiers to the CRT display.

Also, the routine is used to allow proper phasing and amplitude control to be verified for the actual array signal path.

CALLING SEQUENCE

The routine is executed by simply typing a "2" when the EXECUTIVE calls for the next type of analysis. However, all tables and parameters required for calibration (enumerated below) must have been appropriately initialized prior to execution. This initialization is accomplished with the Edit routine.

DESCRIPTION OF INPUT

The user is requested to enter a set of control and analysis variables via the display. Each request is made individually. For example, "SELECT ARRAY TYPE (1, 2 or 3) AR =" is displayed when the array type is to be entered. Following this request will appear the last value that

was entered for this request.* If the user wants to retain this value, he simply hits a carriage return. However, if he wants to change the value, he enters the new value and this hits a carriage return.

The following is the list of user entered data and structure:

Input Data	Format	Neumonic	Initial Default Value	Comments
1. Array Type	I	TYP	1	The index of the table in which calibration data will be stored based on array type (1, 2, or 3).
2. Table No.	I	IFTAB	1	1, 2, 3: the second level index for the calibration table
3. Reference Hydrophone (or channel)	I	IRC	1.0	
4. Frequency	F	FREQ		
5. Bandwidth	F	BW		

FREQ/BW must be an integer.

*When the current execution is the first time through the calibration routine, default values are displayed.

DESCRIPTION OF OUTPUT

A calibration table is displayed giving both absolute and normalized amplitudes and phases for each channel. The table also displays user entered data. Amplitudes are in dBv and phase is in degrees. A sample calibration table summary is shown in Figure 2.

The primary result of the calibration routine is a calibration table. This table is keyed by the array type (TYP) and the table number (IFTAB). A total of nine tables can be generated. Each table is 128 words long. The table contains the complex reciprocal of the rectangular representation of the normalized, unskew corrected DFT analysis coefficients. Each pair of 64 coefficients are stored in alternating sequence. The first (and all subsequent odd numbered elements up to 127) corresponds to an X coordinate and the second (and all subsequent even numbered elements up to 128) corresponds to a Y coordinate.(All vectors having this structure are said to have the "alternating form.") Note that the internally stored calibration table differs from the displayed "normalized" array in that the calibration table is the unskew corrected, complex reciprocal of the "normalized" array.

ERRORS AND RESTRICTIONS

When the user enters a value which is out of the acceptable range, the request for the data is repeated. That is, an error is indicated by a repeated question.

USER INSTRUCTIONS

To enter the calibration routine from the executive, simply type "2" and a carriage return. The user then answers the questions. The

FIGURE 2

AUTOMATIC CALIBRATION   10 SEPT. 74   01:54:40

FTYPE= 1

TYPE = 1 TABLE = 1 FREQ. =   BANDWIDTH =   CH. = 1

CH.	ABSOLUTE AMP. (DB)	ABSOLUTE PHASE (DEG)	NORMALIZED AMP. (DB)	NORMALIZED PHASE (DEG)	CH.	ABSOLUTE AMP. (DB)	ABSOLUTE PHASE (DEG)	NORMALIZED AMP. (DB)	NORMALIZED PHASE (DEG)
1	+.01	+309.83	+.00	+.00	33	+.00	+309.83	-.00	+359.99
2	-.01	+309.81	-.02	+359.97	34	+.00	+309.80	-.00	+359.96
3	+.01	+309.73	+.00	+359.89	35	+.00	+309.74	-.00	+359.90
4	+.00	+309.89	-.00	+.00	36	+.00	+309.81	-.01	+359.97
5	-.01	+309.73	-.02	+359.89	37	+.01	+309.77	-.00	+359.93
6	+.01	+309.76	+.00	+359.93	38	+.00	+309.82	-.00	+359.90
7	+.01	+309.83	+.00	+.00	39	+.01	+309.92	-.00	+.08
8	+.00	+309.82	-.01	+359.83	40	-.00	+309.89	-.01	+359.88
9	+.01	+309.76	+.00	+359.92	41	-.00	+309.81	-.01	+359.98
10	+.00	+309.83	-.00	+359.89	42	+.00	+309.81	-.00	+359.90
11	+.00	+309.70	-.00	+359.87	43	+.00	+309.80	-.00	+359.96
12	+.01	+309.88	+.00	+.04	44	-.00	+309.77	-.01	+359.83
13	+.01	+309.79	+.00	+359.95	45	+.00	+309.80	-.00	+359.98
14	+.00	+309.76	-.00	+359.93	46	+.00	+309.83	-.00	+359.99
15	-.00	+309.80	-.01	+359.97	47	+.00	+309.79	-.00	+359.95
16	+.00	+309.82	-.01	+359.98	48	+.00	+309.77	-.00	+359.93
17	+.00	+309.76	-.00	+359.93	49	+.00	+309.91	-.00	+.08
18	+.00	+309.78	-.01	+359.95	50	+.01	+309.79	+.00	+359.95
19	+.00	+309.80	-.01	+359.98	51	+.01	+309.84	+.00	+.00
20	+.00	+309.81	-.00	+359.98	52	+.00	+309.85	-.01	+.01
21	+.01	+309.76	+.00	+359.92	53	+.01	+309.80	+.00	+359.97
22	+.00	+309.83	-.00	+359.99	54	+.00	+309.78	-.00	+359.95
23	-.01	+309.78	-.03	+359.92	55	+.00	+309.82	-.00	+359.98
24	+.00	+309.79	-.01	+359.95	56	+.00	+309.81	-.00	+359.97
25	+.00	+309.80	-.00	+359.98	57	+.01	+309.81	+.00	+359.97
26	+.00	+309.82	-.00	+359.99	58	-.00	+309.80	-.01	+359.96
27	+.01	+309.79	+.00	+359.96	59	+.01	+309.77	+.00	+359.93
28	+.00	+309.83	-.00	+.00	60	+.00	+309.80	-.00	+359.98
29	+.00	+309.87	-.00	+.04	61	+.00	+309.80	-.00	+359.96
30	+.01	+309.81	+.00	+359.97	62	+.00	+309.80	-.00	+359.98
31	+.00	+309.81	-.01	+359.98	63	+.00	+309.76	-.00	+359.92
32	-.00	+309.76	-.01	+359.92	64	-.00	+309.83	-.01	+359.99

range of acceptable values is displayed along with the request. Array type, table number, and reference hydrophone all must be entered without a decimal point. Each entered value must be followed by a carriage return. (Keying errors can be corrected by hitting the DELETE key if a carriage return has not been made.) The last value entered is displayed and the user has the option to: (1) simply hit a carriage return if the value need not change for the current calibration table, or (2) enter a new value.

After the calibration table has been displayed, the user can make a hard copy by manually activating the hard copy device.

The user must then release the display by typing an "R." The calibration routine is then completed. The user is then given the opportunity to generate another calibration table or return to the executive.

DESCRIPTION OF PROCESSING

Refer to the Generalized Flow Diagram.

1. Enter calibration parameters.
2. Compute and store DFT coefficients (Subroutine DFTCI).
3. Compute and store DFT analysis output coefficients (Subroutine DFTD). This subroutine provides the software interface to the hardware input raw data.
4. Use complex division to normalize the output of the DFTD subroutine to the selected reference channel.
5. Create the skew correction table as a function of frequency and sampling rate (Subroutine SKEW).

6. Calculate skew corrected absolute DFT output coefficients by performing a complex multiplication (using Subroutine MATX) between the output of the DFTD routine and the skew correction table.

7. Calculate the skew corrected normalized DFT output coefficients by performing a complex multiplication between the normalized DFT results (from (4)) and the skew correction table.

8. Print calibration table of absolute and normalized skew corrected DFT results in dB for amplitude and degrees for phase.

9. Calculate and store the actual calibration table by taking the complex reciprocal of the normalized, but unskew corrected DFT coefficients previously calculated under (4).

10. Store the frequency and bandwidth used for generation the current calibration table.

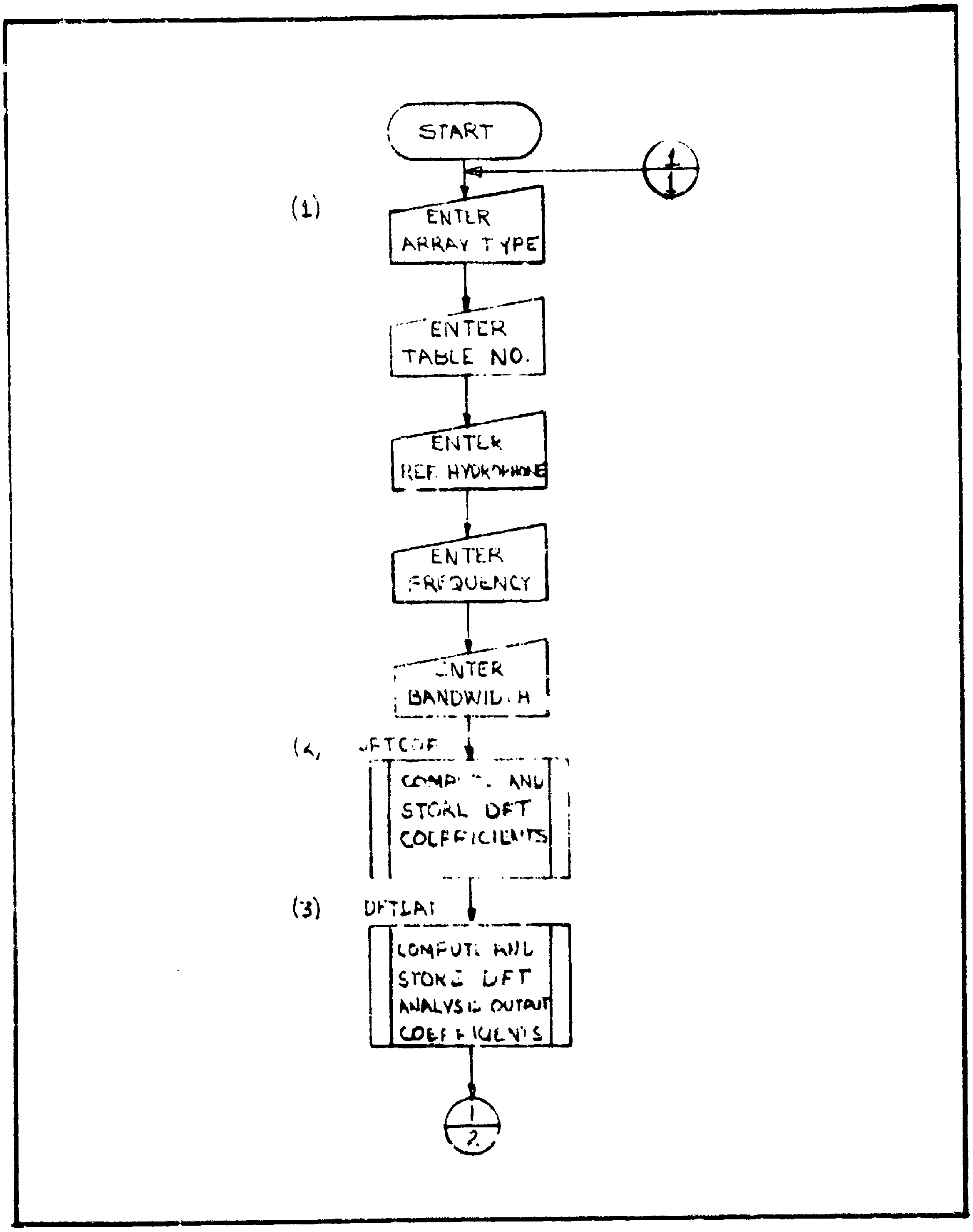

Figure 3 : AUTOMATIC CALIBRATION Page 1 of 3

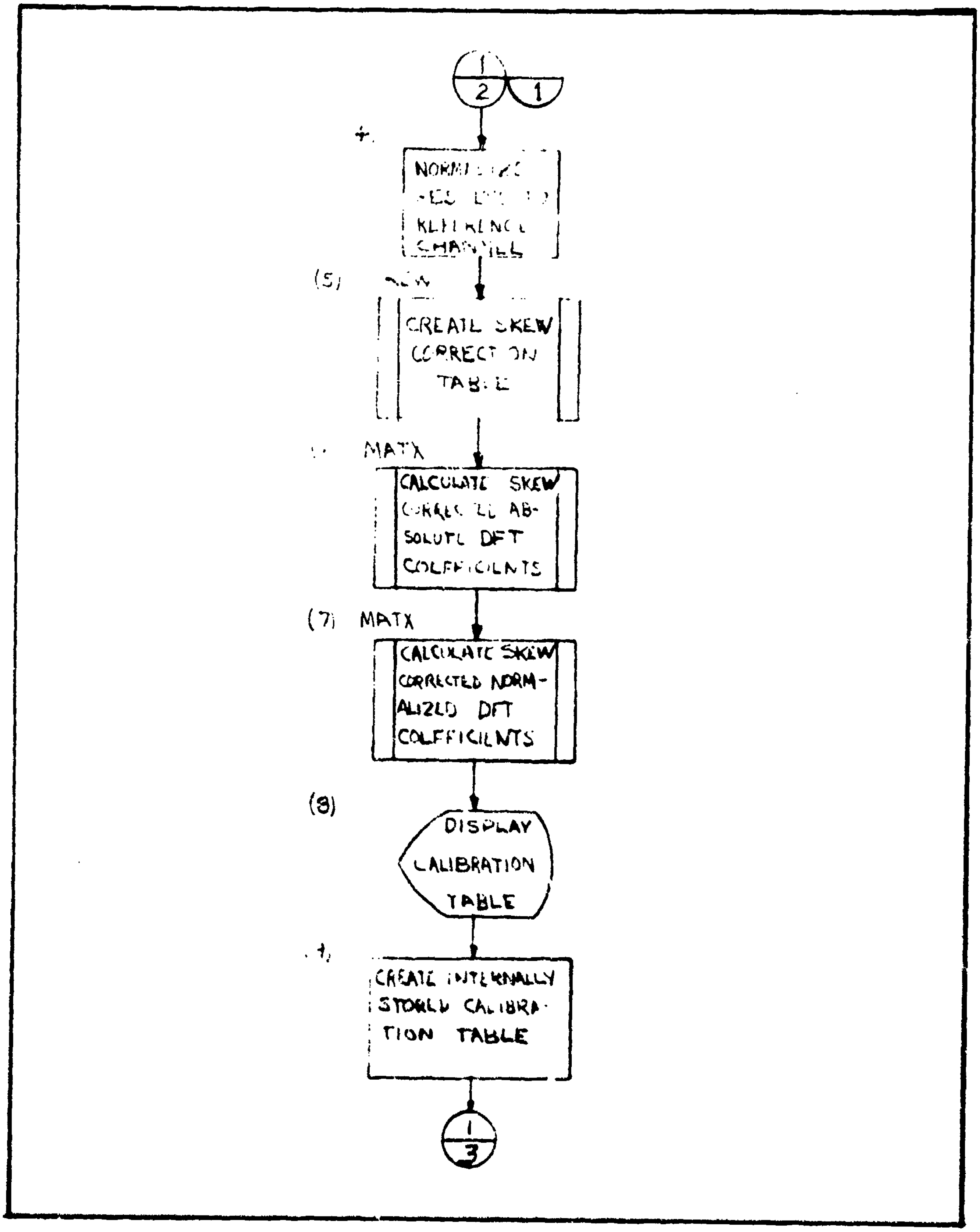

Figure 2 : AUTOMATIC CALIBRATION

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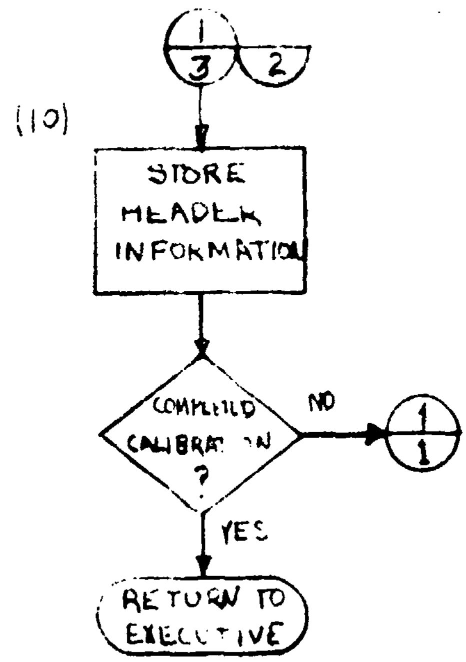


Figure 3 : AUTOMATIC CALIBRATION **Page** 3 **of** 3

BEAMFORMING ROUTINE

INTRODUCTION

Beamforming is done by using real-time, digital phasing techniques. In the computer, one beam sample is calculated from:

$$D = \Sigma \; A_i \times B_i \times C_i$$

where

D = the beam sample

A_i = the i-th signal amplitude and phase (from the DFT routine)

B_i = the i-th channel amplitude and phase correction factors (from the calibration routine)

C_i = the amplitude and shading coefficients (from the STRPH).

A, B, and C are all arrays of complex numbers, rectangular form, and elements in length. The complex D will represent the beam sample at a specific analysis frequency and a specific analysis bandwidth. Results are ultimately displayed both in tabular and graphical form.

CALLING SEQUENCE

The routine is executed by simply typing a "1" when the EXECUTIVE calls for the next procedure. Execution of the beamforming routine assumes that all required tables and parameters have been appropriately initialized. This includes an appropriate calibration table.

DESCRIPTION OF INPUT

The user is requested to enter a set of control and analysis variables via the display, as well as set three sense switches. The sense switches:

(1) allow execution of the routine to be delayed until a specific time, (2) allow bypassing the plotting routine, and/or (3) allow the updating of the master accumulator table (which is used to cumulate overall summary data). User entered data is requested in the same manner as for the calibration routine, namely: (1) the request for data is made followed by the current value of the input variable, (2) if the user simply hits a carriage return, the current value is unchanged and becomes the new value to be used, and (3) otherwise, the user's entered value replaces the current value after a carriage return is typed.

A list of user entered data follows together with the format that is expected (I = integer, F = floating point) and the mnemonic used in the program.

	Input Data	Format	Mnemonic	Comments
1.	Array Type	I	TYP	1, 2, or 3
2.	Table Number of Shading Coefficients	I	ISHD	1, 2, or 3
3.	Range of Steer Angles	F	PHMN, PHMX	The minimum and maximum steer angles to be used such that $-90.0° \leq PHMN < PHMX \leq 90.0°$ (90.0° is forward and 0.0° is broadside.)
4.	Quantity of Steer Angles to be used	I	NSA	
5.	Steer Angle Increment Mode	I	INMOD	1 = sin (θ) 2 = θ Steer angles between PHMN and PHMX can be generated based on equal increments in sine or simply equal angles.
6.	Bandwidth	F	BWI,BW	

	Input Data	Format	Mnemonic	Comments
7.	Quantity of frequencies to be generated	I	NF	$1 \le NF \le 8$
8.	Input Frequency Mode	I	MDFRQ	1=discrete 2=swept 3=retain This gives the user the option of: (1) entering NF specific frequencies, (2) creating NF frequencies, each separated by one bandwidth, or (3) retaining the previous set of frequencies.
9.	(Only if MDFRQ=1) Frequencies	F	FRQ(*)	The set of NF discrete frequencies
10.	(Only if MDFRQ=1) Vector of calibration table to be used	I	CALDX(*)	The set of NF indices to the calibration tables. Each element can be 1, 2, or 3. (Note that CALDX(I) will be used in conjunction with FRQ(I) only).
11.	(Only if MDFRQ=2) First frequency in sequence	F	FRQ(1)	One frequency only; the range of possible values will be displayed with the request since the maximum is a function of BW.
12.	(Only if MDFRQ=2) Calibration table number	I	CALDX(1)	One number, 1, 2, or 3 to be used for all frequencies in the sweep.
13.	Averaging Mode	I	AMOD	1=simple averaging 2=exponential averaging
14.	(Only if AMOD=2) Exponential Averaging Time	F	TAU	$.2 \le TAU \le 10^6$
15.	No. of samples per plot (i.e., the sample size)	I	NS	--
16.	No. of group of NF frequencies to be plotted	I	NG	Such that $1 \le NG \cdot NF \le 32$. The number of sets of NF frequencies to be displayed on the graph.

DESCRIPTION OF OUTPUT

The primary outputs of the beamforming routine are:

1. Graphs (amplitude versus steer angle)
2. Plot Data Table
3. Master Accumulator Table

The first two are summaries of the current run whereas the master accumulator table summarizes data over a series of selected runs.

Graphs

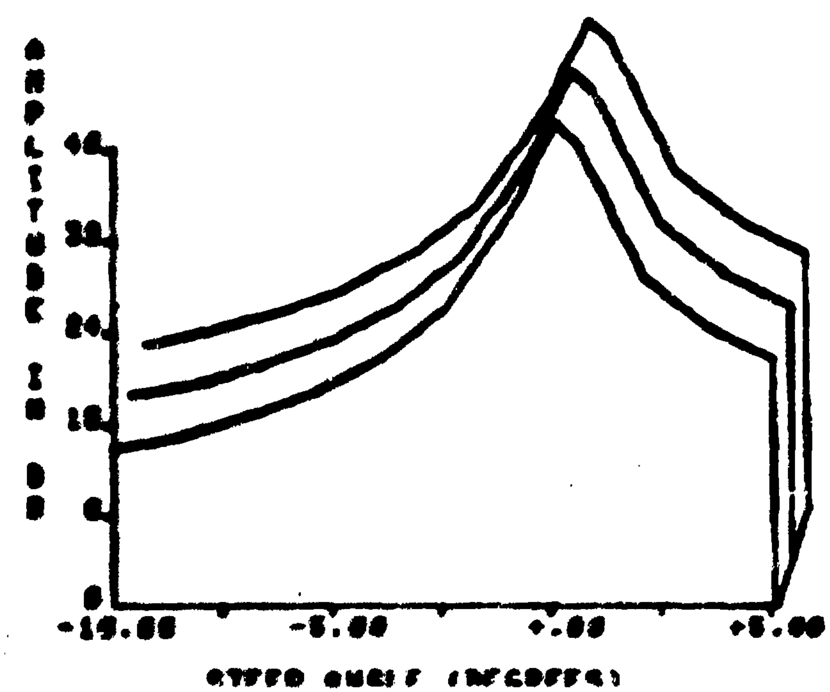
The header of each graph contains the following supportive information:

1. The array type
2. The type of filtering used
3. The index number of the shading coefficients table used
4. A sequential list of calibration tables used for the respective frequencies
5. The number of samples for each frequency
6. The exponential averaging time
7. The bandwidth in Hz
8. The date
9. The time the current run was initiated
10. A scale factor that should be used to translate DB-V (e.g.) DB-μV. This scale factor is input via the EDIT routine and plays no part whatsoever in any of the computations. It is simply an annotating device.

Figure 4 shows a sample graph with all but the first axes removed. To the right of each plot is its respective frequency in hertz.

FIGURE 4

```
ARRAY TYPE=    1  FTYPE=    1
SHADING TABLE NO.=    1
CAL. TABLES= 1
SAMPLE SIZE/FREQ.= 001
AVERAGING TIME=     +.25
BANDWIDTH=
DATE/TIME     18 SEPT. 74   01:54:40
SCALE FACTOR=  +4.35
```



Plot Data Table

The Plot Data Table is the tabular results of what was displayed on the graph. It displays the amplitude (in DB-V) for each of the selected steer angles over each of the selected frequencies. See Figure 5.

The header contains the following information:

1. The date
2. The time
3. The number of updates (does not apply for this table, see below)
4. The scale factor (see explanation under Graph)
5. The filtering type
6. The array type
7. The shading coefficient table number
8. The list of calibration tables with respect to frequencies
9. The sample size
10. The exponential averaging time
11. The bandwidth

Master Accumulator Table

This table has the same basic structure as the plot data table. The only difference being the title and the parameter indicating the number of times this table has been updated since last cleared. See Figure 6.

USER INSTRUCTIONS

The beamforming routine is entered by typing "1" when in the EXECUTIVE.

The user should then set sense switches if he wants to delay execution or eliminate the plots or bypass updating the master accumulator table. The user then answers the questions displayed.

FIGURE 5 -

```
            PLOT DATA TABLE         19 DEPT. 74  01:04:40
NUMBER OF UPDATES=   0  SCALE FACTOR  +4.35  FTYPE=   1
TYPE=   1 SHADING TABLE NO.=   1  CAL. TABLE= 1
SAMPLE SIZE= 001  AVERAGING TIME=   +.20  BANDWIDTH=
STR. ANGLE      ---------------------AMPLITUDE (DB)---------------------
   (DEG)   FREQ./
 -10.00         +13.00
  -8.40         +15.00
  -6.80         +18.83
  -5.40         +18.75
  -3.80         +21.00
  -2.50         +25.00
  -1.00         +34.22
   +.00         +42.25
   +.40         +40.57
  +1.80         +20.00
  +3.40         +24.30
  +4.80         +21.05
```

FIGURE 6

```
         MASTER ACCUMULATOR TABLE  10 SEPT. 74  01:54:40
NUMBER OF UPDATES=    5  SCALE FACTOR  +4.35  FTYPE=   1
 TYPE=   1 SHADING TABLE NO.=   1  CAL. TABLE= 1
 SAMPLE SIZE= 001  AVERAGING TIME=   +.20  BANDWIDTH=
STR. ANGLE     --------------------AMPLITUDE (DB)--------------------
   (DEG)  FREQ./
  -10.00          +28.74
   -8.40          +27.56
   -6.90          +25.85
   -5.40          +32.88
   -3.90          +42.86
   -2.50          +44.18
   -1.00          +48.22
    +.00          +49.03
    +.40          +48.65
   +1.80          +33.05
   +3.40          +28.85
   +4.50          +24.40
```

The first question gives the user an opportunity to rerun the routine using the old input parameters. Typing an "N" to the question, "NEW INPUT PARAMETERS," will bypass all of the questions and go directly to execution. A "Y" will start the display of input questions.

The range of acceptable values is displayed along with each request. Each entered value must be followed by a carriage return. (Keying errors can be corrected by using the DELETE key if a carriage return has not been made.) The last value entered (i.e., from the previous run) is also displayed, and the user has the option to hit a carriage return if the value need not change for the current run or enter a new value. A sample of the question set is shown in Figure 7. The questions themselves are self-explanatory. The last question gives the user a chance to escape back to the start of the question set if he has made a mistake before actual execution is started. Typing a carriage return indicates an acceptance of all answers to the questions and actual execution is then started.

If, however, sense switch "0" has been set (indicating that the user wants to delay the run until a specific time), the user is asked to enter the time at which he would like execution to commence. He should enter the time as shown in the following example (with colons).

14:23:30

Follow this with a carriage return (as usual). Execution will then start exactly when the system clock reaches the input start time.

After all plots have been completed, the user can make a hard copy of the display if he wishes. Then, typing an "R" releases the screen and the plot data table is displayed. If the user requested more than 33 steer angles, a second page will be displayed when the first has been released.

FIGURE 7

```
PLEASE SET DESIRED SENSE SWITCHES
SETTING:  SS0 WILL REQUEST START TIME
          SS1 WILL BYPASS PLOTTING
          SS2 WILL BYPASS UPDATING THE MASTER ACCUMULATOR TABLE

NEW INPUT PARAMETERS? (Y OR N)  Y
SELECT ARRAY TYPE (1=LOW, 2=MED, 3=HIGH)  1
SELECT TABLE OF SHADING COEFFICIENTS (1, 2, or 3)  3
ENTER RANGE OF STEER ANGLES
(-90 to +90, 90 DEG.=FORWARD, 0 DEG.=BROADSIDE)
 -40.00
 +40.00
THERE ARE 41 INDEPENDENT ANGLES

ENTER NO. OF STEER ANGLES (1-64)  64
SELECT STEER ANGLE INCREMENT MODE BASED ON EQUAL INCREMENTS OF
  1=SIN(PHI) OR 2=PHI 2
ENTER BANDWIDTH (HZ)

ENTER TOTAL NUMBER OF FREQUENCIES (1-8) TO BE USED  1
ENTER SELECTION OF INPUT FREQ. MODE:
1=DISCRETE, 2=SWEPT, 3=RETAIN PREVIOUS SET  1
ENTER  1 FREQ.   (HZ)
  1
ENTER VECTOR OF CALIBRATION TABLES 1 to 1 ELEMENTS, EACH ELEMENT 1, 2, OR 3
  1 1
SELECT AVERAGING MODE: 1=SIMPLE  2=EXPONENTIAL  1
ENTER TOTAL NUMBER OF SAMPLES PER PLOT
DOES THE USER WISH TO CLEAR THE MASTER ACCUMULATION TABLE (Y OR N)  N
ENTER NO. GROUPS OF 1 FREQ. TO PLOT  (1-32)  1
RETURN TO GO, ANYTHING ELSE REPEATS QUESTIONS
INPUT START TIME  HR:MIN:SEC
```

Unless the master accumulator has not been updated (sense switch 2 has been set), this table is displayed after the last page of the plot data table has been released.

DESCRIPTION OF PROCESSING

Refer to the Generalized Flow Diagram (Figure 8).

1. Enter and/or generate parameters and program control variables.
2. Generate the isometric plot axis and display input data.
3. Precompute the DFT coefficients as a function of the center frequency and the analysis bandwidth (subroutine DFTCI).
4. Perform the DFT on one signal sample (subroutine DFTD).
5. Calculate the complex matrix product of the output from DFTD and the appropriate calibration table.
6. Precompute constants used in calculating the amplitude and phase shading coefficients.
7. Calculate the amplitude and phase shading coefficients and calculate one beam sample using fixed point arithmetic.
8. Update the plot data table using either simple or exponential averaging.
9. Plot one line on the display. This graph represents the average amplitude (in DB) for a specific frequency over the entire range of steer angles.
10. Update the master accumulator table, if required. This table can be used to summarize data over a series of runs of the beamforming routine.
11. Display the plot data table.
12. Display the master accumulator table if updated.

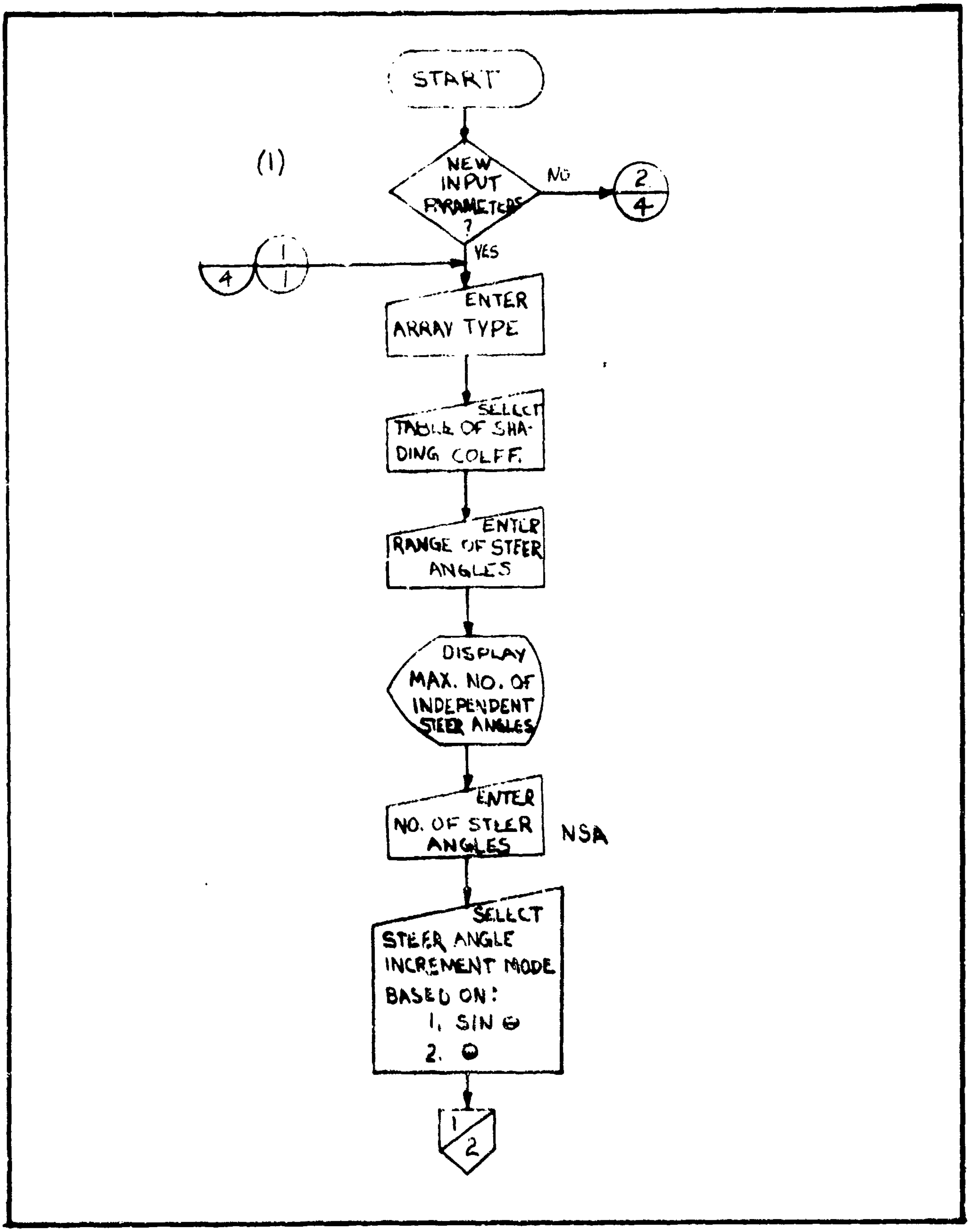


Figure 8 : BEAMFORMING

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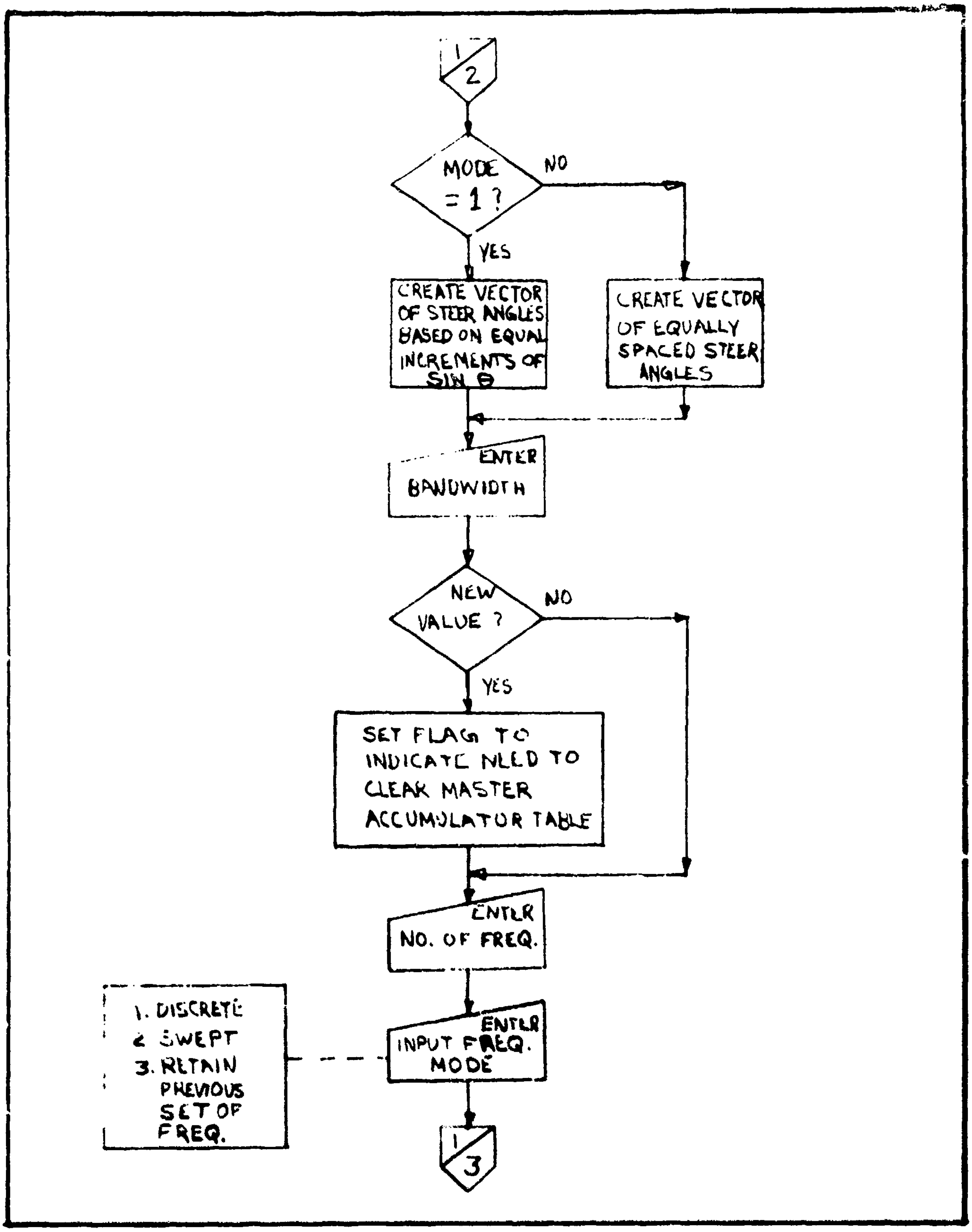

Figure 8 : BEAMFORMING Page 2 of 7

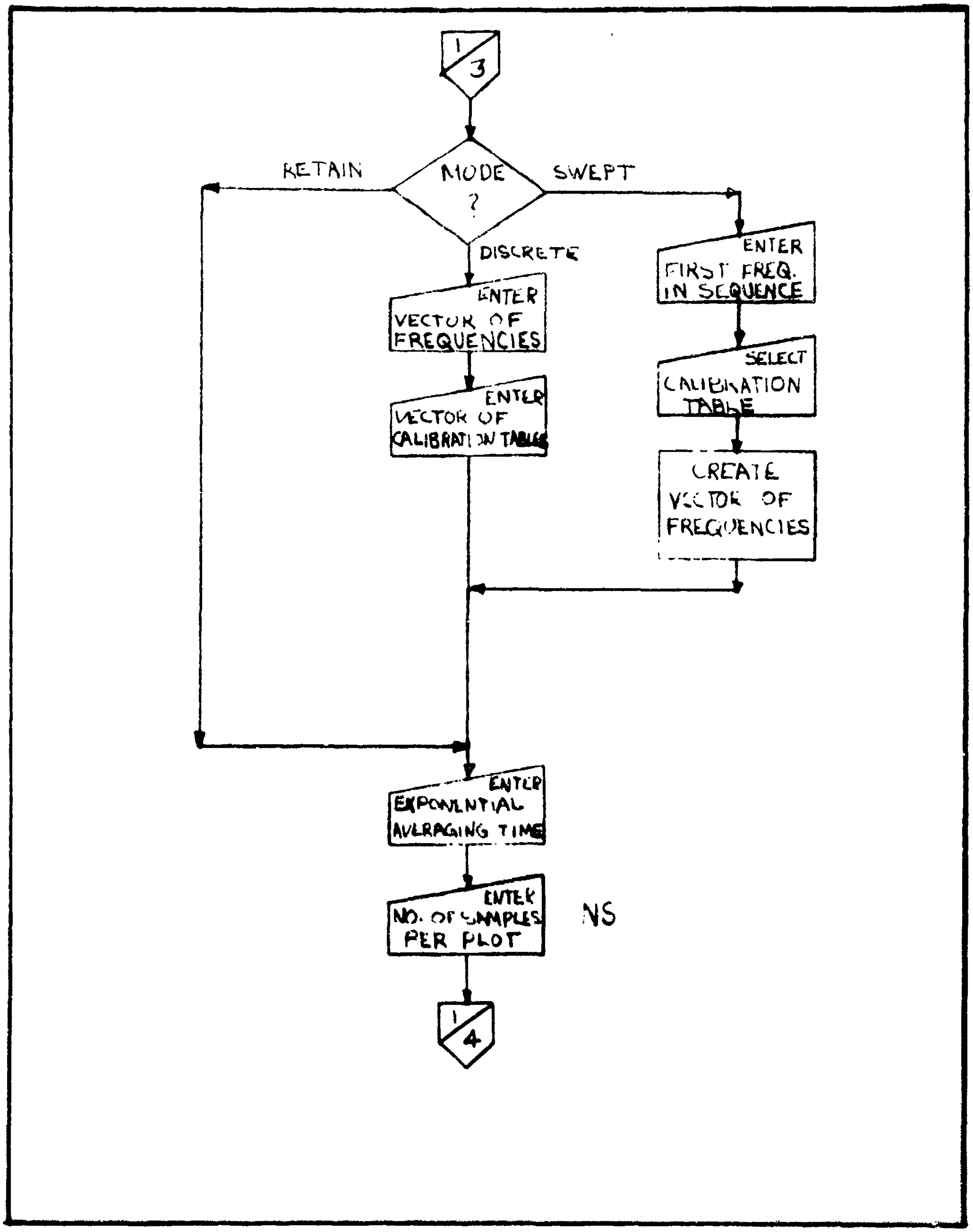

Figure 8 : BEAMFORMING

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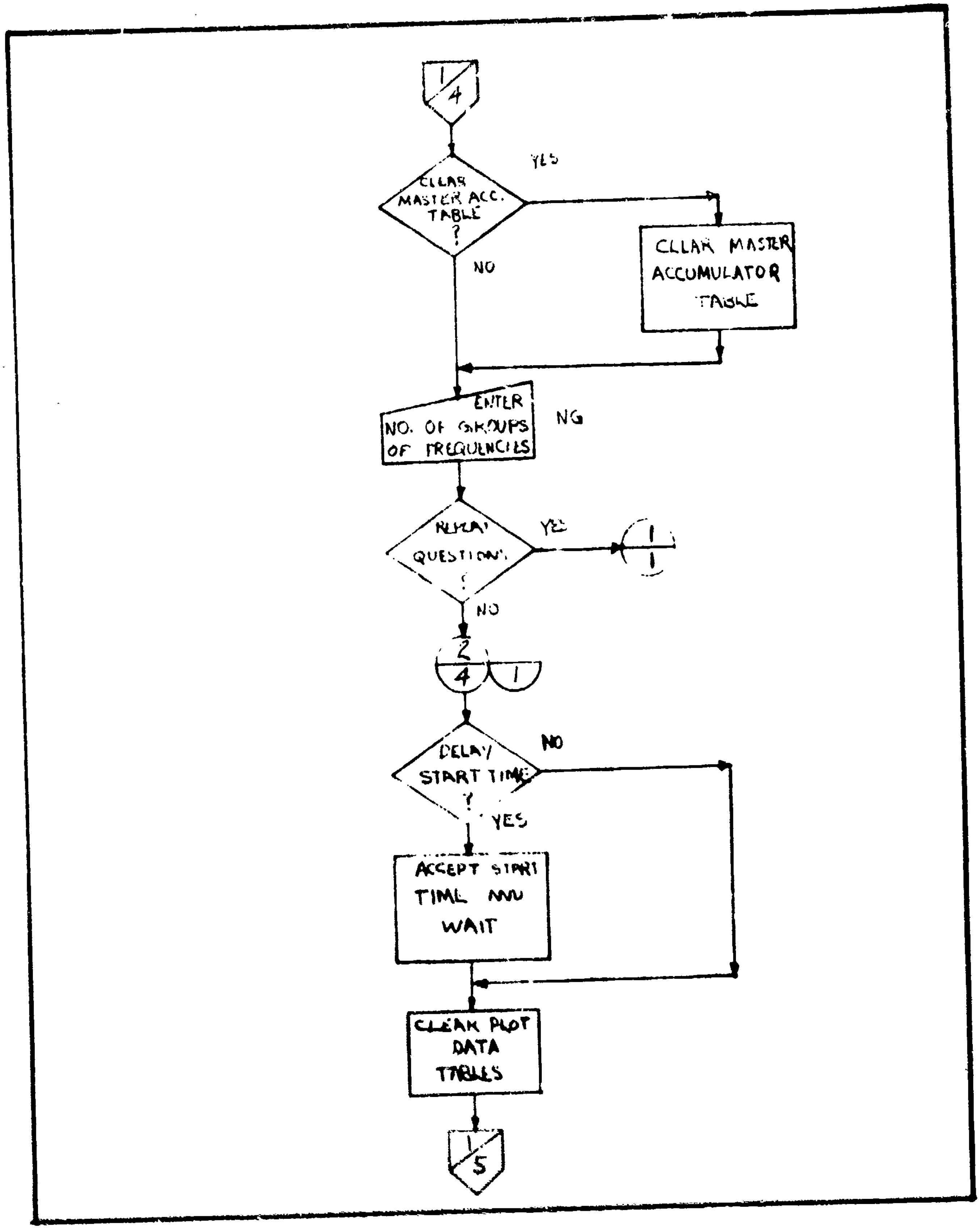

Figure 8 : BEAMFORMING

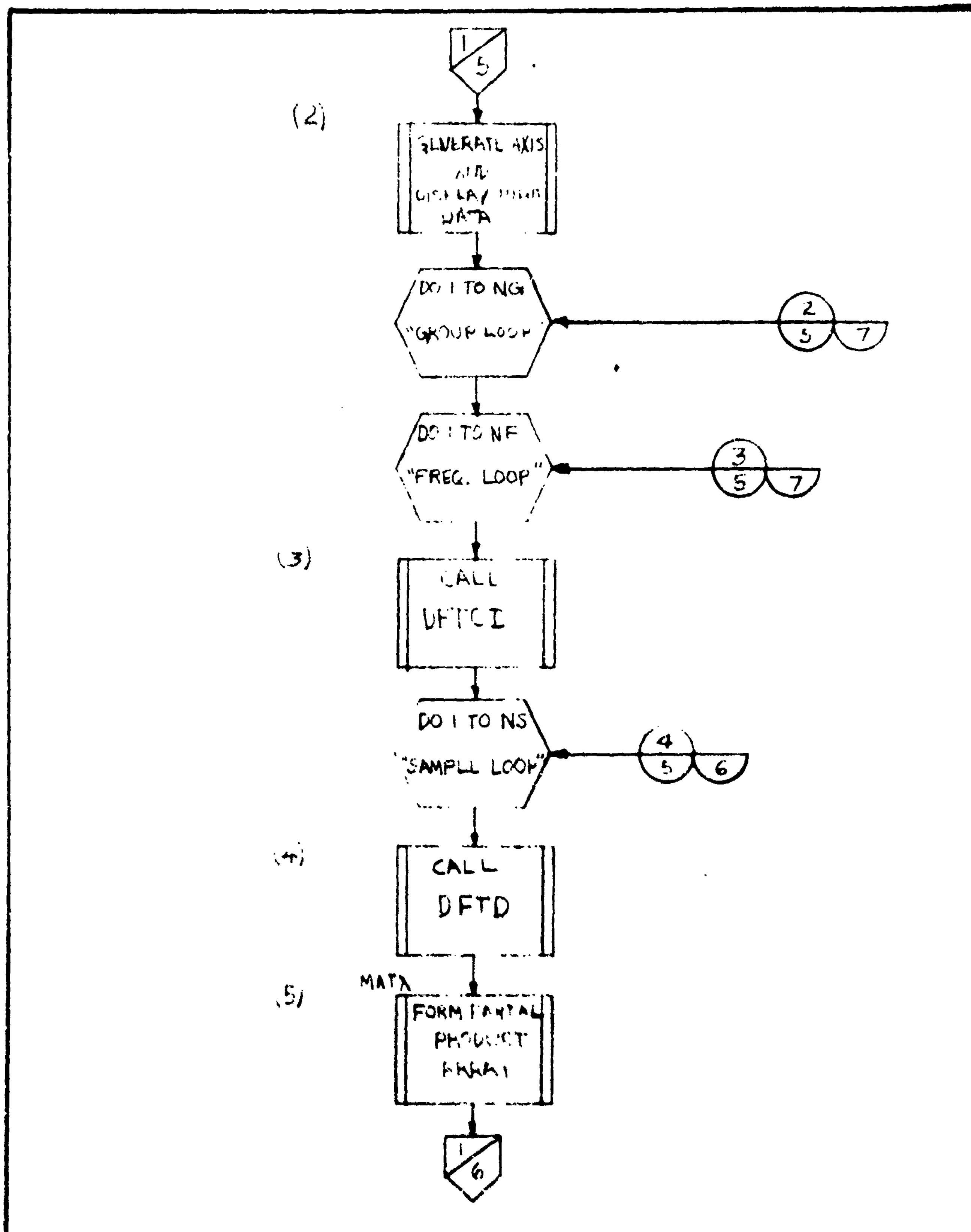

Figure F : BEAMFORMING **Page** 5 **of** 7

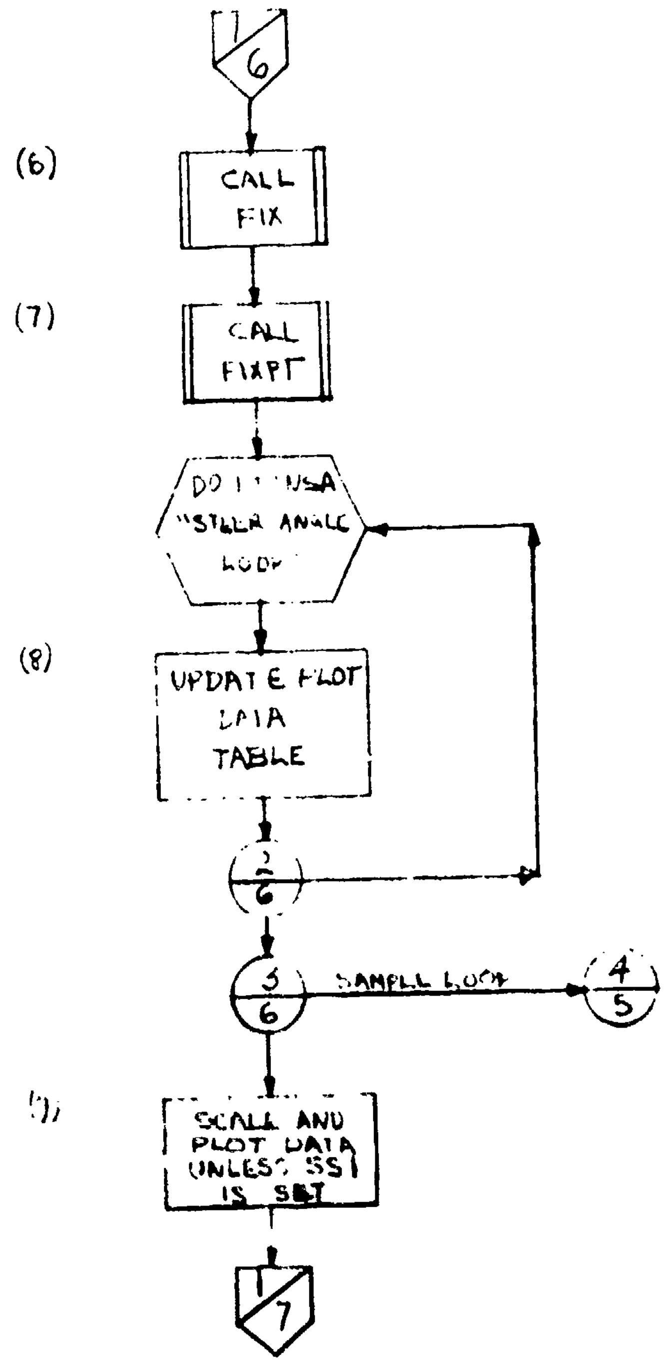

Figure 8 : BEAMFORMING

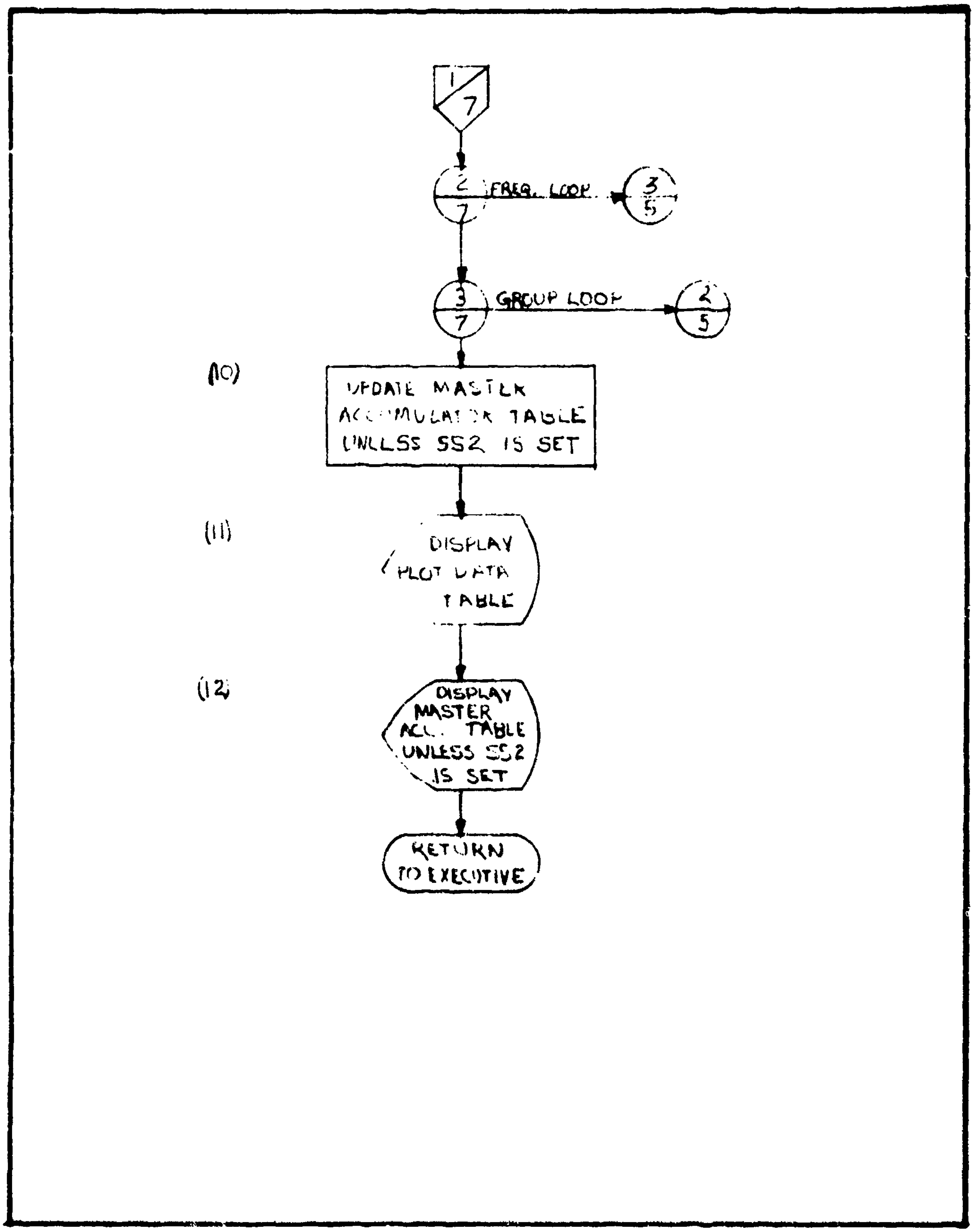

Figure 6 : BEAMFORMING **Page** 1 **of** 7

EDIT ROUTINE

INTRODUCTION

The EDIT routine is used to perform any of the following functions:

1. Change the date that is displayed on all tabular summaries and graphs.
2. Change any or all elements of the amplitude shading coefficients table.
3. Change any of the basic plot format items (e.g., width or height of a plot, distance between successive plots, etc.).
4. Display any internally stored calibration table.
5. Change any of the values of array spacing.
6. Change the velocity of sound parameter.
7. Select any of three methods of DFT analysis: (1) Conventional, (2) Hanning, and (3) Wag

CALLING SEQUENCE

The EDIT routine is only called from the EXECUTIVE routine by typing a "3." Editing is usually one of the first activities the user will perform in setting up subsequent analyses.

DESCRIPTION OF INPUT

All input data is entered via the display. As before, the user is presented a series of questions or options. His answers and selections determine what and how data is to be edited.

DESCRIPTION OF OUTPUT

When single valued parameters are to be edited, their current value is displayed. The user can then determine if he wishes to retain the

current value (by simply hitting carriage return) or changing the value.

Tables subject to editing (exclusively the amplitude shading coefficient tables) are displayed in their entirety before actual changes can be made. (See Figure 9.)

Option "4" simply displays one entire calibration table as it is stored internally. No alteration of the table can be made with the EDIT routine. (Such alterations must be performed by rerunning the AUTOMATIC CALIBRATION routine.) An example is shown in Figure 10.

USER INSTRUCTIONS

The user enters the EDIT routine by typing a "3." The following is then displayed:

EDIT OPTIONS

1. DATE
2. AMPL
3. PLOT FORMAT
4. PRINT CALTB
5. SPACING
6. C EDIT
7. DFT EDIT

CHOICE =

FIGURE 9

SHADING COEF. TABLE

1	+1.00	17	+1.00	33	+1.00	49	+1.00
2	+1.00	18	+1.00	34	+1.00	50	+1.00
3	+1.00	19	+1.00	35	+1.00	51	+1.00
4	+1.00	20	+1.00	36	+1.00	52	+1.00
5	+1.00	21	+1.00	37	+1.00	53	+1.00
6	+1.00	22	+1.00	38	+1.00	54	+1.00
7	+1.00	23	+1.00	39	+1.00	55	+1.00
8	+1.00	24	+1.00	40	+1.00	56	+1.00
9	+1.00	25	+1.00	41	+1.00	57	+1.00
10	+1.00	26	+1.00	42	+1.00	58	+1.00
11	+1.00	27	+1.00	43	+1.00	59	+1.00
12	+1.00	28	+1.00	44	+1.00	60	+1.00
13	+1.00	29	+1.00	45	+1.00	61	+1.00
14	+1.00	30	+1.00	46	+1.00	62	+1.00
15	+1.00	31	+1.00	47	+1.00	63	+1.00
16	+1.00	32	+1.00	48	+1.00	64	+1.00

SET ENTIRE TABLE TO SINGLE VALUE (Y OR N)

FIGURE 10

CALIBRATION TABLE

TYPE = 1 TABLE NUMBER= 1

FREQ.= +20.00 BW= +1.00

CH.	REAL	IMAG.	CH.	REAL	IMAG.
1	+1.00	+.00	33	+.99	+.07
2	+.99	+.00	34	+.99	+.07
3	+.99	+.00	35	+.99	+.07
4	+.99	+.00	36	+.99	+.07
5	+1.00	+.00	37	+.99	+.08
6	+1.00	+.01	38	+.99	+.08
7	+.99	+.01	39	+.99	+.08
8	+.99	+.01	40	+.99	+.08
9	+.99	+.01	41	+.99	+.08
10	+.99	+.02	42	+.99	+.09
11	+1.00	+.02	43	+.99	+.09
12	+.99	+.02	44	+.99	+.09
13	+.99	+.02	45	+.99	+.09
14	+.99	+.03	46	+.99	+.10
15	+.99	+.03	47	+.99	+.10
16	+.99	+.03	48	+.99	+.10
17	+.99	+.03	49	+.99	+.10
18	+.99	+.03	50	+.99	+.10
19	+.99	+.04	51	+.99	+.11
20	+.99	+.04	52	+.99	+.11
21	+.99	+.04	53	+.99	+.11
22	+.99	+.04	54	+.99	+.11
23	+.99	+.05	55	+.99	+.12
24	+.99	+.05	56	+.99	+.12
25	+.99	+.05	57	+.99	+.12
26	+.99	+.05	58	+.99	+.12
27	+.99	+.05	59	+.99	+.12
28	+.99	+.06	60	+.99	+.13
29	+.99	+.06	61	+.99	+.13
30	+.99	+.06	62	+.99	+.13
31	+.99	+.06	63	+.99	+.14
32	+.99	+.06	64	+.99	+.14

The user makes his choice by entering the selected index number. Following is a description of each of the options:

1. DATE

   Option 1 responds by displaying the entire date (e.g., 30 NOV 74). Then day, month, and year are displayed respectively, and, after each, the user must either retain the current value (which has also been displayed) by hitting return, or he must change the value. Months are entered as integers 1 to 12, and the year is represented by only the last two digits, i.e., 74.

2. AMPLITUDE SHADING COEFFICIENTS TABLE

   Option 2 responds by asking which of the three possible amplitude shading coefficients tables the user wishes to edit. The selected table is then displayed (e.g., see Figure 9). The user is then given the option to edit a specific element or set all elements to a constant. If the latter is chosen, the user must enter the specific constant to which all elements are to be set. After all elements have been assigned, processing continues in the single element edit mode.

   Single elements in a table are edited by selecting the element number (1 to 64) and then entering a value. (As always, a numerical response must be followed by a carriage return.) Typing of just a return after "ELEMENT NO. =" appears, escapes editing of this table. The user may then either continue editing another shading coefficients table or return to the edit options list.

3. PLOT FORMATS

Option 3 allows the user to alter the dimensions of the plots. The following nine parameters are displayed and edited, one by one.

DZX - The X-distance (in plot points*) from absolute "0" (on the screen) to "0" on the first plot axis.

DZY - The Y distance (in plot points) from absolute "0" (on the screen) to the origin of the first axis.

IWD - The width of one plot axis (in plot points).

IHI - The height of one plot axis (in plot points).

DX - The X distance (in plot points) from one plot origin to the next.

DY - The Y distance from one plot origin to the next.

LSW - The light switch, "0" removes all plot axes but the first; "1" includes all axes on the plot.

YMIN - The lowest value (in DB) to be displayed on the vertical scale.

SCF - The range (in DB) of the vertical scaling (note that the highest scaling number on the vertical axis is SCF - YMIN).

Actual data plots will be truncated below YMIN, but will not be truncated above (SCF-YMIN), the highest scale value.

*There are approximately 100 points per inch vertically and 115 points per inch horizontally.

4. PRINT CALIBRATION TABLE

Option 4 simply asks the user to select a specific table and then displays it. The user can, at this point, make a hard copy if he so desires. A return to the edit option list is accomplished by typing an "R" to release the screen.

5. SPACING

Option 5 allows the user to enter the array spacing (in feet) for each of three array types. The first spacing parameter will be used when array type one has been called for. Similarly for array types two and three. Each respective spacing parameter is displayed as it currently is stored and the user can enter a new value or retain the old. A carriage return after editing the third spacing parameter returns to the edit option list.

6. VELOCITY OF SOUND (C).

Option 6 allows the user to edit this single valued parameter expressed in feet per second.

7. DFT EDIT

Option 7 allows the user to select the type of filtering he wishes to employ; 1 is a straight DFT (rectangular window); 2 employs a Hanning window; and 3 uses a Wag window. After making the selection, the user is requested to enter a DFT scale factor. This simply is a constant that is used to annotate every output. It does not affect plotted or tabulated outputs in any way.

When the user has finished editing, he can return to the EXECUTIVE by typing a carriage return whenever a choice is to be made from the edit option list.

DESCRIPTION OF PROCESSING

The processing is relatively simple since it basically involves the following steps (for all but Option 4):

1. Select data to edit.
2. Display current value or values.
3. Change or retain current value.
4. Continue edit or return to executive.

The following flow diagrams are self explanatory.

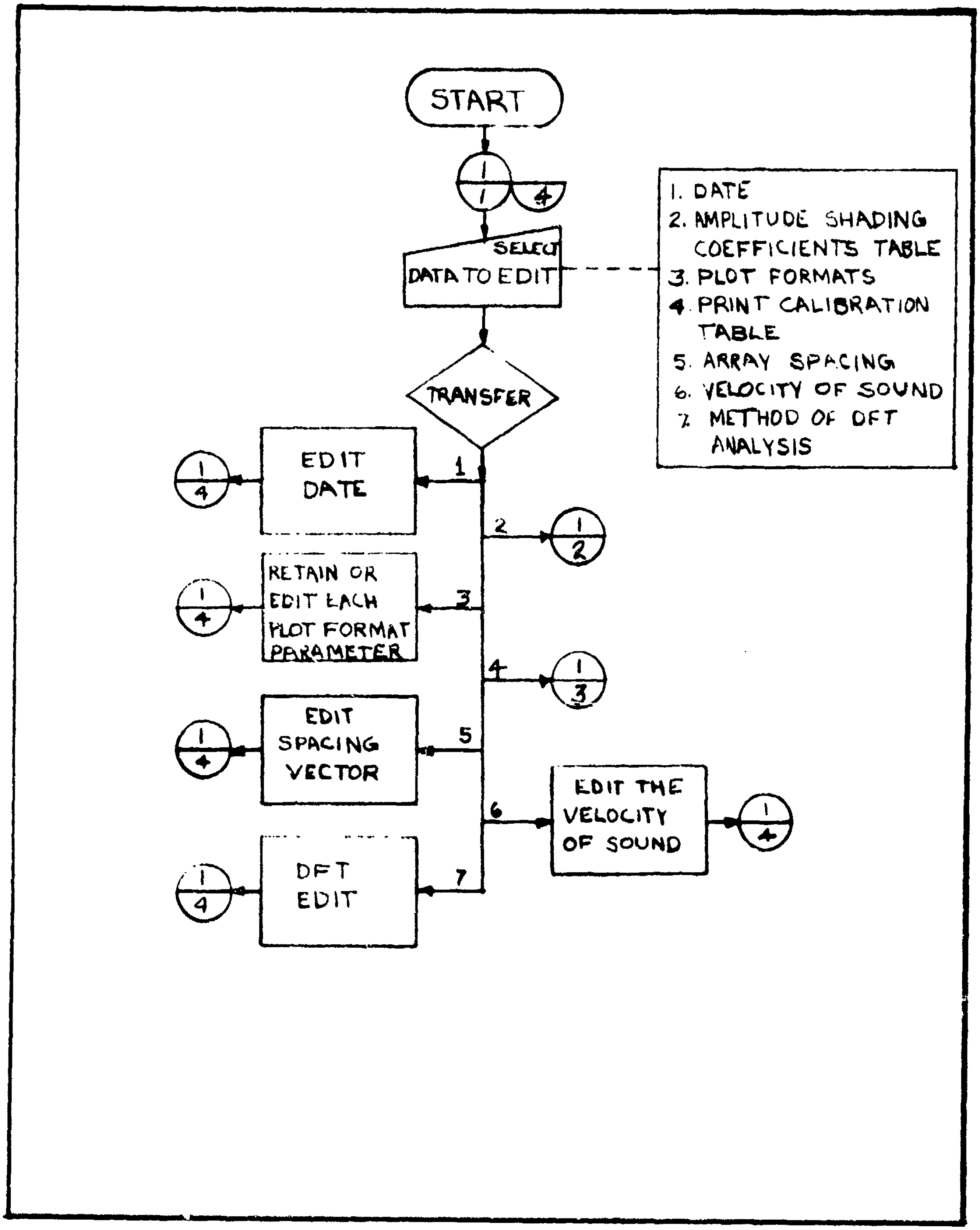

Figure 11 : EDIT

Page 1 of 4

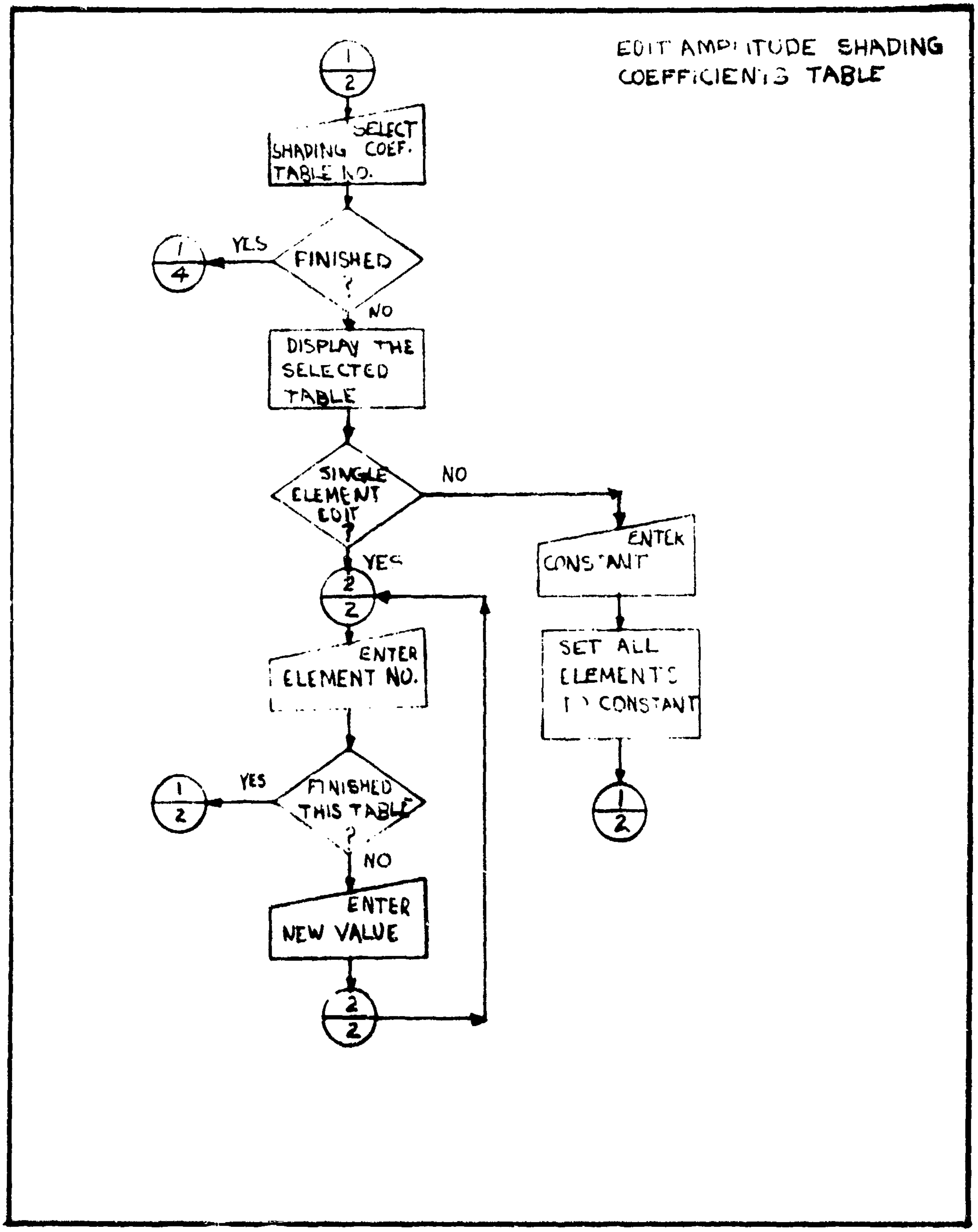

Figure 11 : EDIT

Page 2 of 4

PRINT CALIBRATION TABLE

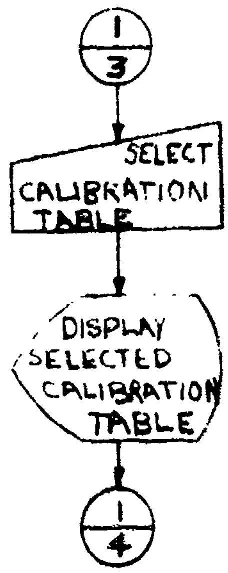

Figure 11 : EDIT

Page 3 of 4

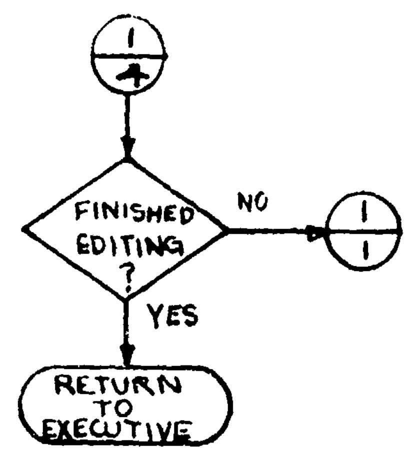

Figure 11 : EDIT

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PUNCH TABLES ROUTINE

INTRODUCTION

This routine allows the user to store the calibration tables on paper tape. In addition to the calibration table, the routine punches the amplitude shading coefficients and a table containing header information for each of the calibration tables.

CONSTRAINTS

This routine punches only a specific section of core, specifically, that section containing:

1. The calibration tables
2. The amplitude shading coefficients
3. The header table.
4. The Spacing Table

CALLING SEQUENCE

This routine is called as one of the options of the EXECUTIVE routine. The program is usually executed following generation of the calibration tables, thereby allowing the subsequent use of the calibration tables without requiring their regeneration via execution of AUTOMATIC CALIBRATION.

DESCRIPTION OF OUTPUT

The sole output of this routine is a paper tape containing 2724 words of data in binary.

USER INSTRUCTION

This routine is entered from the executive by simply typing "4" and a carriage return. The user is then reminded (via the display) to turn

the paper tape punch on. The user must then type any key. This starts the punching of the tables. On completion, control is returned to the executive for further processing instructions.

DESCRIPTION OF PROCESSING

The entire routine consists of a call to subroutine PUNCH. This subroutine is passed the beginning address of the first calibration table, the last address of the last header table, and the address to which the loader is to return on completion.

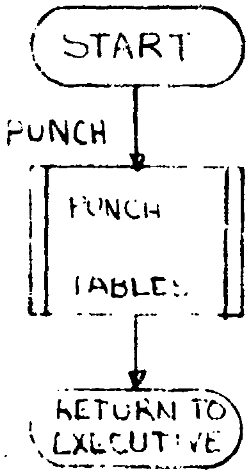

Figure 12 : PUNCH TABLES

Page 1 **of** 1

PUNCH PROGRAM

INTRODUCTION

This routine copies all programs onto paper tape. Internally stored data is not punched by this routine. (Selected tables can be punched using the PUNCH TABLES routine.)

CALLING SEQUENCE

The program is only accessible from the executive routine. It is entered by typing a "5."

DESCRIPTION OF OUTPUT

The sole output of this routine is a paper tape containing approximately 14K words of program in binary.

USER INSTRUCTIONS

The routine is entered from the executive by typing a "5" and a carriage return. The user is then reminded (via the display) to turn on the paper tape punch and then type any character. This initiates the punching of the first of two sections of core. The user is notified (via the display) when the first section has been completed. The user should, at this point, cut off this segment of tape since keeping both sections on one tape will make the fan-folded paper tape slightly unwieldly. The punching of the second section is started by typing any character. On completion, control is returned to the executive for further processing instructions.

DESCRIPTION OF PROCESSING

The entire routine consists of two sequential calls to subroutine PUNCH. The first call passes the beginning address of the first core section of programs, its last address, and the address to which the loader is to return on completion. The second call punches the second core section utilizing a similar call.

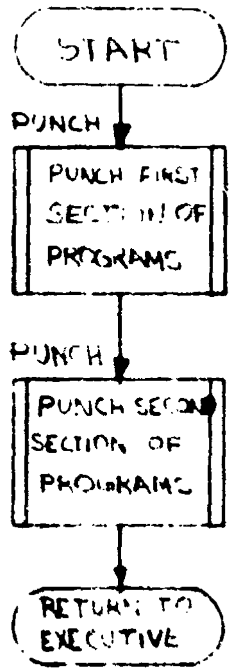

Figure 13: PUNCH PROGRAMS

Page 1 of 1

PUNCH MASTER ACCUMULATOR TABLE ROUTINE

INTRODUCTION

This routine allows the user to store the master accumulator table on paper tape.

CALLING SEQUENCE

This routine is Option 6 of the executive routine. It will be used primarily to store cumulative results for particularly long runs. Subsequent input of this table allows the user to start "where he left off" when reloading the system.

DESCRIPTION OF OUTPUT

The only output of this routine is a paper tape containing 1040 words of data.

USER INSTRUCTIONS

The routine is entered from the executive by typing "6" and a carriage return. The user is then reminded (via the display) to turn the paper tape punch on. The user must then type any key to initiate punching of the table. On completion, control is returned to the executive for further processing instructions.

DESCRIPTION OF PROCESSING

The entire routine consists of a call to subroutine PUNCH. The subroutine is passed the beginning address of the master accumulator table, its last address, and the address to which the loader is to return on completion.

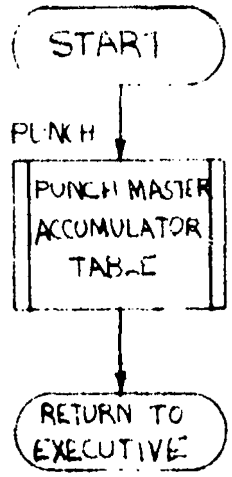

Figure 14 : PUNCH MASTER ACCUMULATOR TABLE

Page 1 of 1

APPENDIX

Detailed flow diagrams are included for the following analysis programs and subroutines:

AUTOMATIC CALIBRATION

(1)

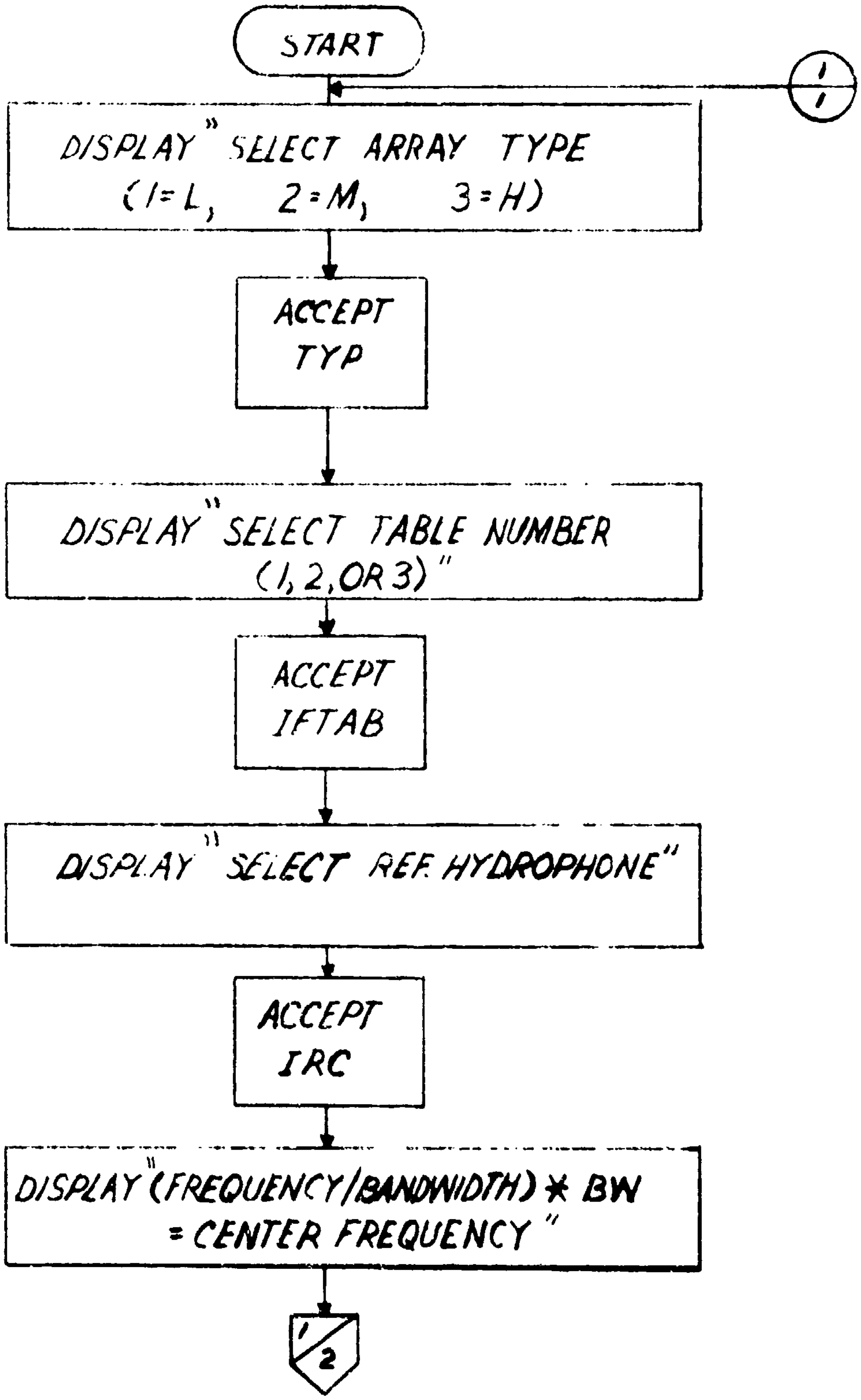

FIG. 1

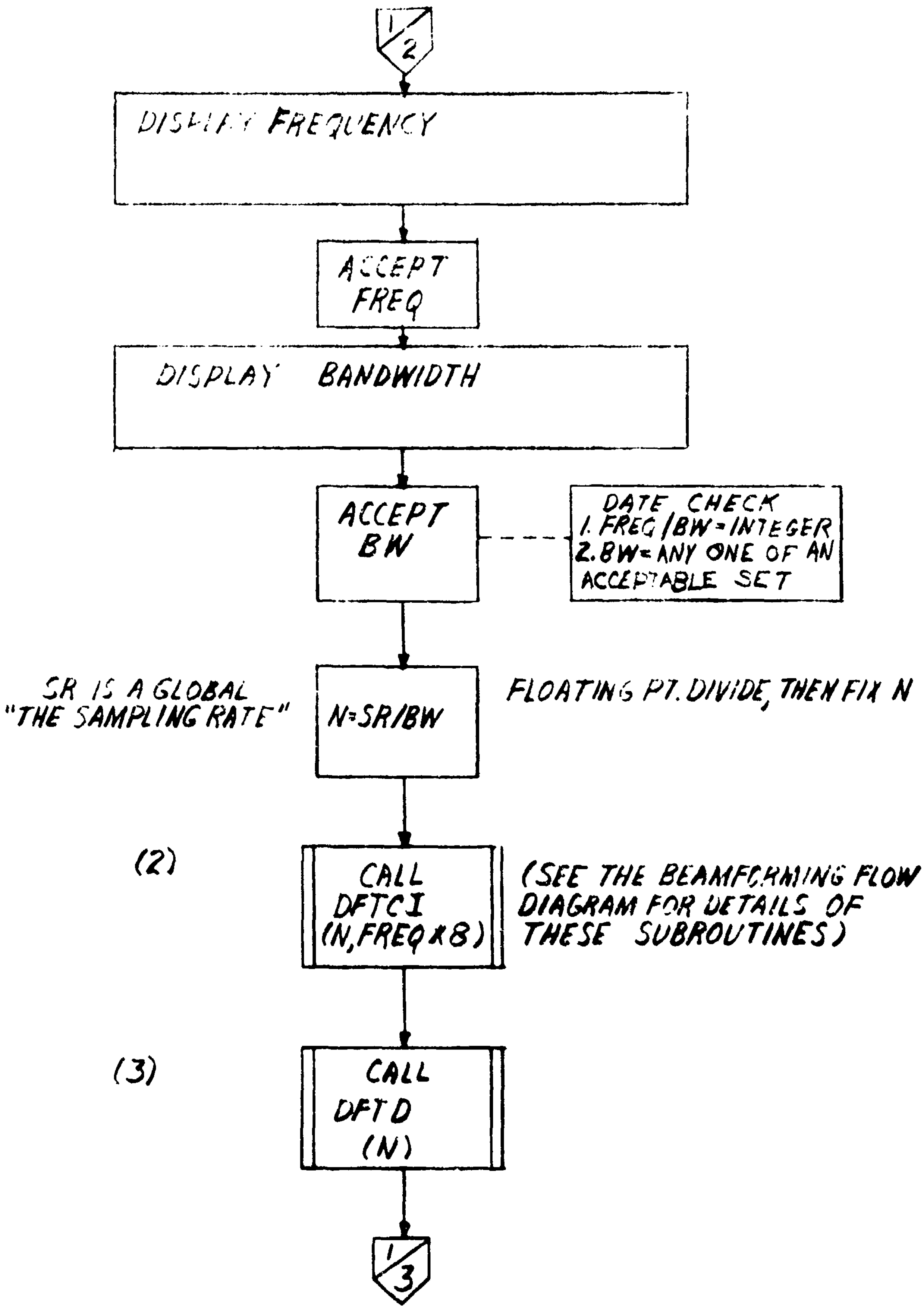
1/2
DISPLAY FREQUENCY
ACCEPT FREQ
DISPLAY BANDWIDTH
ACCEPT BW
DATE CHECK
1. FREQ/BW = INTEGER
2. BW = ANY ONE OF AN ACCEPTABLE SET
SR IS A GLOBAL "THE SAMPLING RATE"
N=SR/BW
FLOATING PT. DIVIDE, THEN FIX N
(2)
CALL DFTCI (N,FREQx8)
(SEE THE BEAMFORMING FLOW DIAGRAM FOR DETAILS OF THESE SUBROUTINES)
(3)
CALL DFTD (N)
1/3

FIG 1

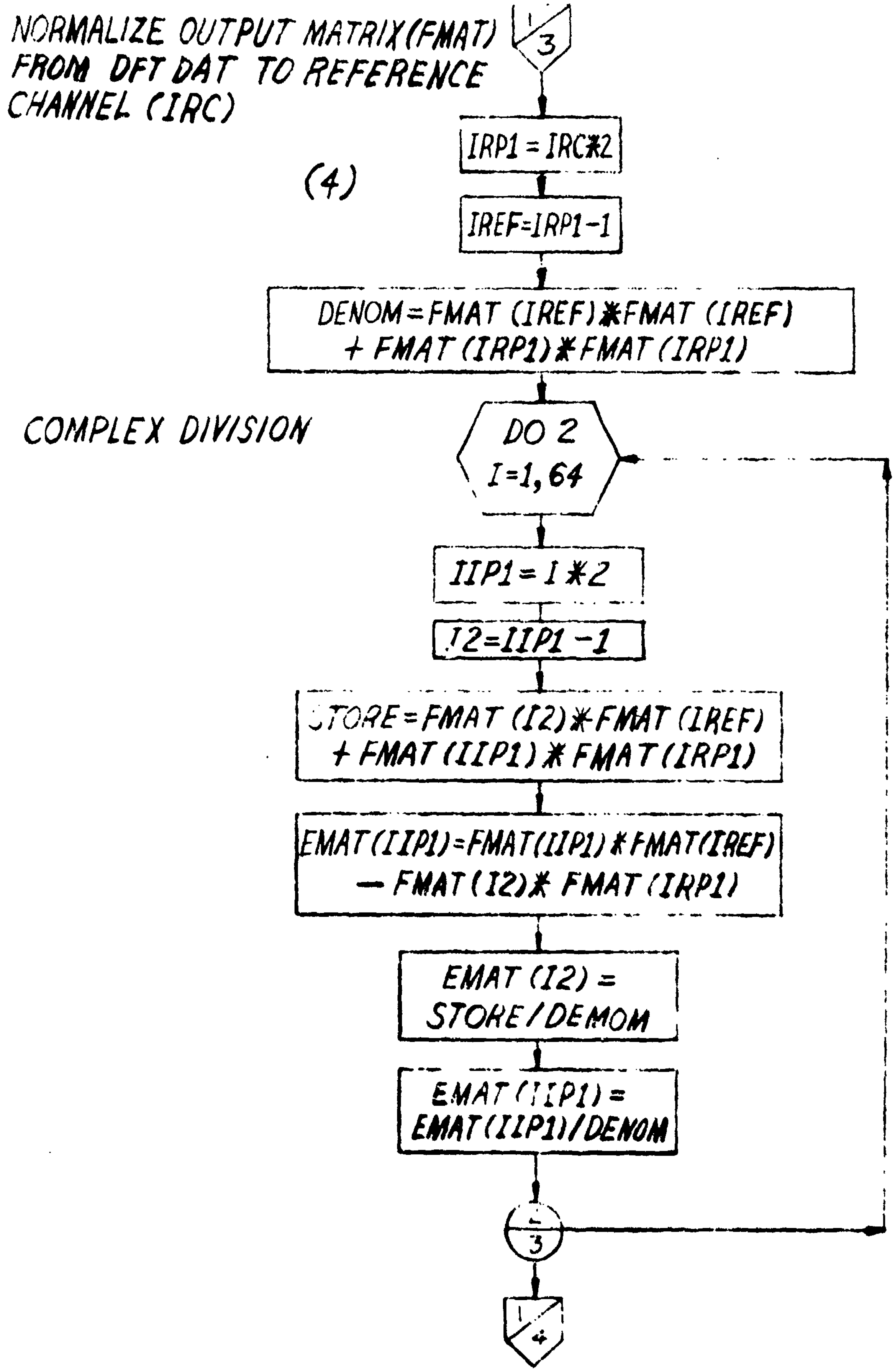
NORMALIZE OUTPUT MATRIX (FMAT) FROM DFT DAT TO REFERENCE CHANNEL (IRC)
1
3
(4)
IRP1 = IRC*2
IREF=IRP1-1
DENOM=FMAT (IREF)*FMAT (IREF) + FMAT (IRP1)*FMAT (IRP1)
COMPLEX DIVISION
DO 2 I=1, 64
IIP1 = I*2
I2=IIP1 -1
STORE=FMAT (I2)*FMAT (IREF) + FMAT (IIP1)*FMAT (IRP1)
EMAT (IIP1)=FMAT (IIP1)*FMAT (IREF) — FMAT (I2)* FMAT (IRP1)
EMAT (I2) = STORE/DEMOM
EMAT (IIP1) = EMAT (IIP1)/DENOM
2
3
1
4

Fig.

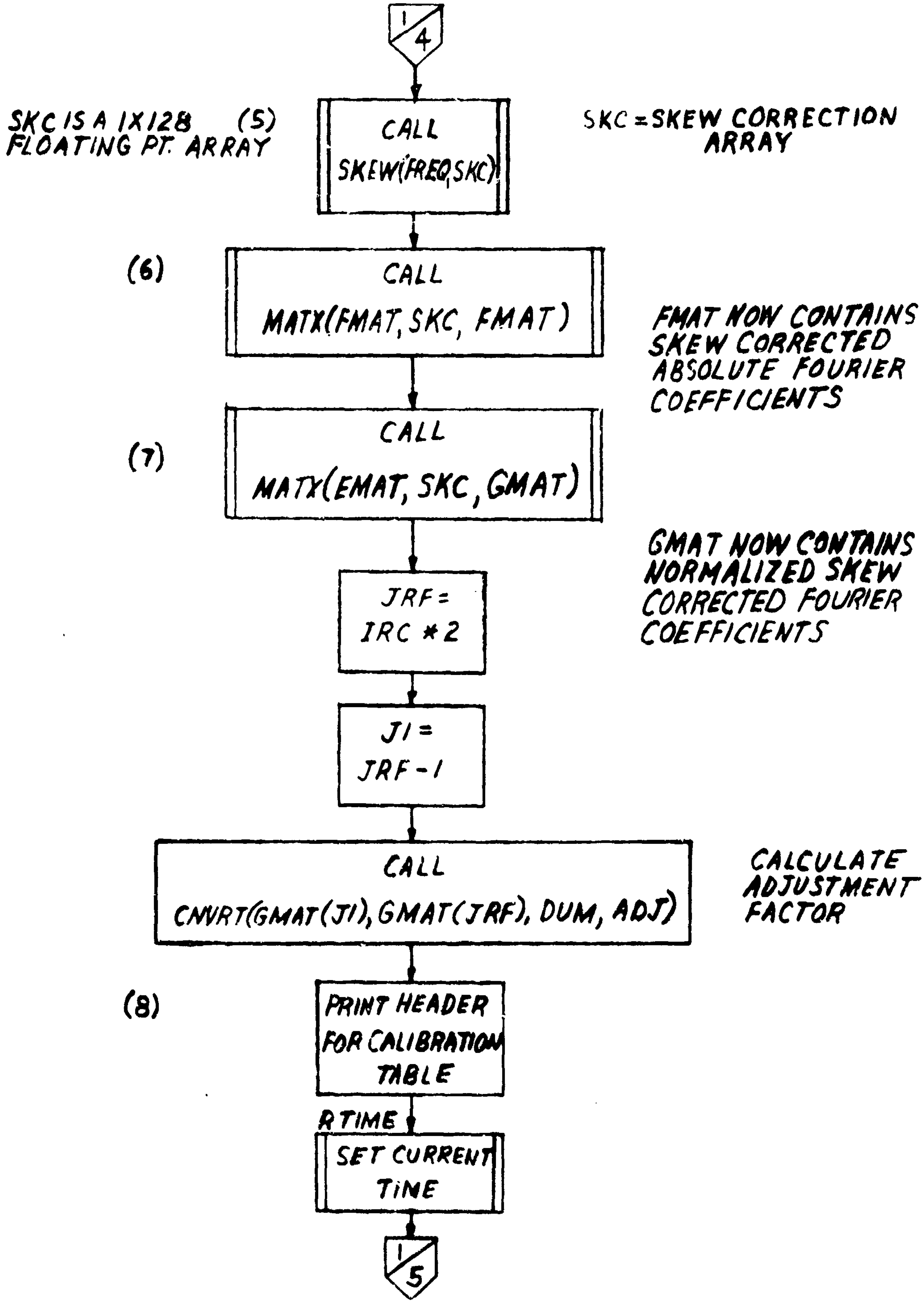
1/4
SKC IS A 1X128 FLOATING PT. ARRAY
(5)
CALL SKEW(FREQ,SKC)
SKC = SKEW CORRECTION ARRAY
(6)
CALL MATX(FMAT, SKC, FMAT)
FMAT NOW CONTAINS SKEW CORRECTED ABSOLUTE FOURIER COEFFICIENTS
(7)
CALL MATX(EMAT, SKC, GMAT)
GMAT NOW CONTAINS NORMALIZED SKEW CORRECTED FOURIER COEFFICIENTS
JRF = IRC * 2
J1 = JRF - 1
CALL CNVRT(GMAT(J1), GMAT(JRF), DUM, ADJ)
CALCULATE ADJUSTMENT FACTOR
(8)
PRINT HEADER FOR CALIBRATION TABLE
RTIME
SET CURRENT TIME
1/5

FIG 1

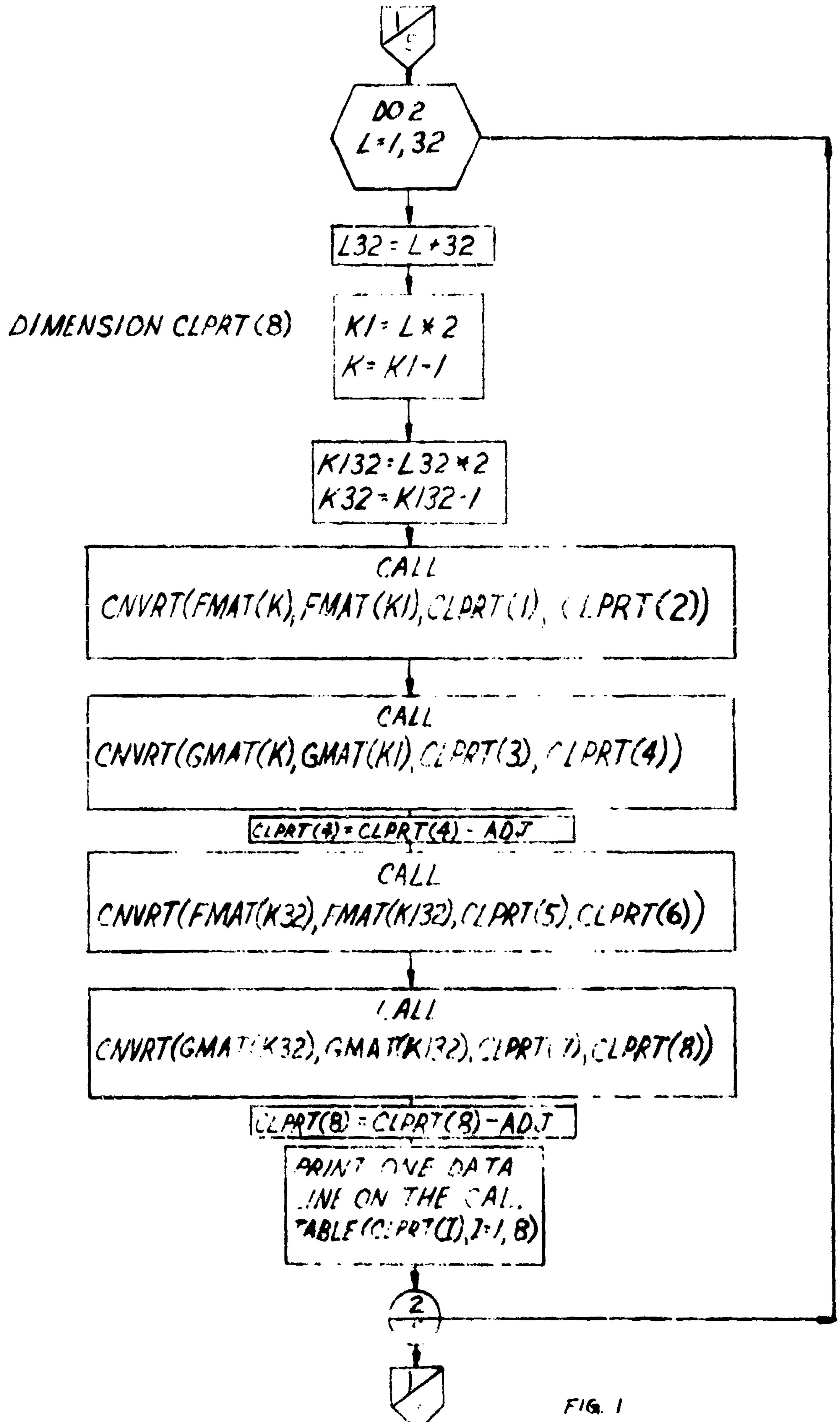
DO 2
L=1,32
L32 = L+32
DIMENSION CLPRT(8)
K1 = L*2
K = K1-1
K132 = L32*2
K32 = K132-1
CALL
CNVRT(FMAT(K),FMAT(K1),CLPRT(1),CLPRT(2))
CALL
CNVRT(GMAT(K),GMAT(K1),CLPRT(3),CLPRT(4))
CLPRT(4) = CLPRT(4) - ADJ
CALL
CNVRT(FMAT(K32),FMAT(K132),CLPRT(5),CLPRT(6))
CALL
CNVRT(GMAT(K32),GMAT(K132),CLPRT(7),CLPRT(8))
CLPRT(8) = CLPRT(8) - ADJ
PRINT ONE DATA
LINE ON THE CAL.
TABLE(CLPRT(I),I=1,8)
2

FIG. 1

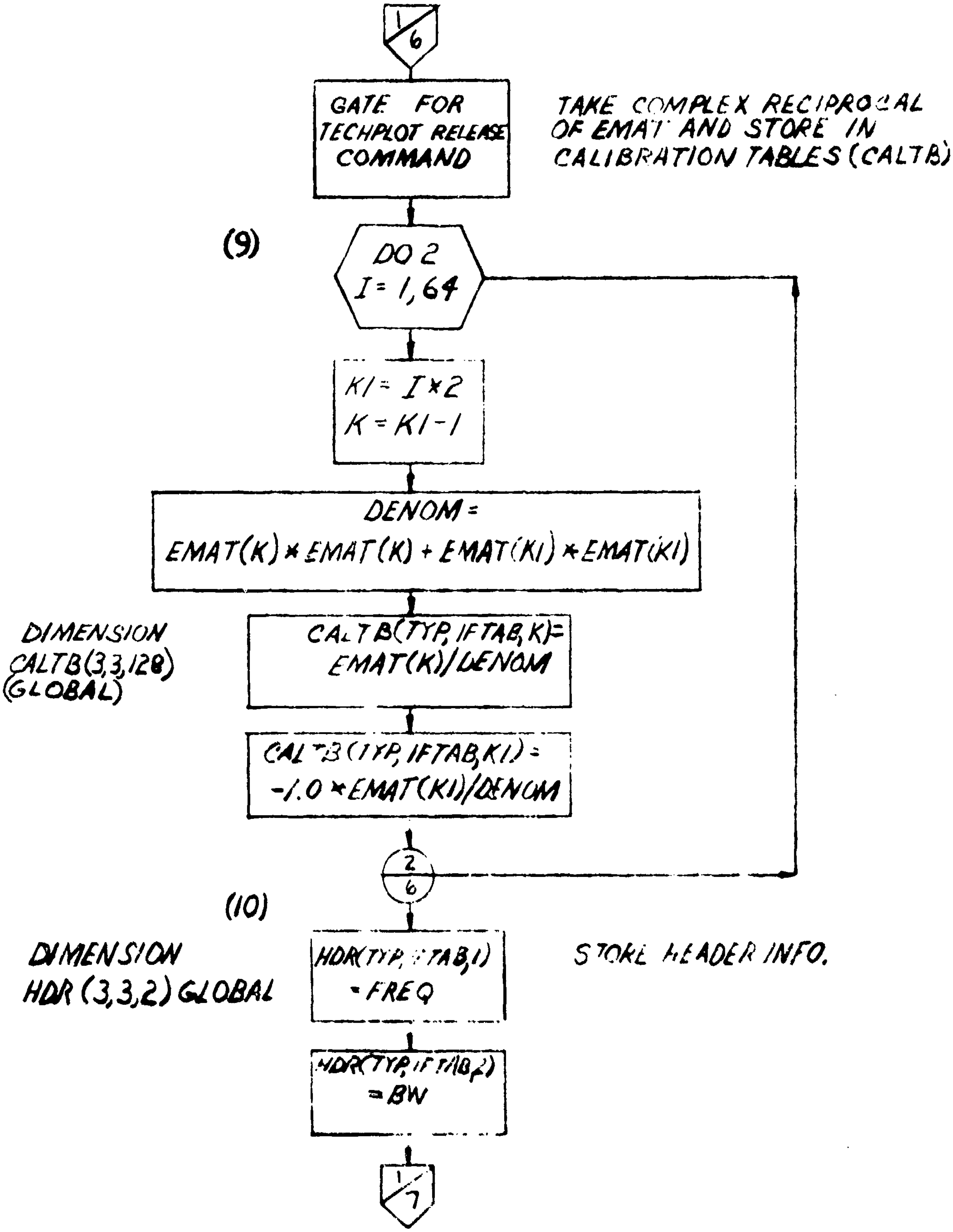
1/6
GATE FOR TECHPLOT RELEASE COMMAND
TAKE COMPLEX RECIPROCAL OF EMAT AND STORE IN CALIBRATION TABLES (CALTB)
(9)
DO 2 I = 1,64
K1 = I*2
K = K1-1
DENOM = EMAT(K) * EMAT(K) + EMAT(K1) * EMAT(K1)
DIMENSION CALTB(3,3,128) (GLOBAL)
CALTB(TYP, IFTAB, K) = EMAT(K)/DENOM
CALTB(TYP, IFTAB, K1) = -1.0 * EMAT(K1)/DENOM
2/6
(10)
DIMENSION HDR (3,3,2) GLOBAL
HDR(TYP, IFTAB, 1) = FREQ
STORE HEADER INFO.
HDR(TYP, IFTAB, 2) = BW
1/7

FIG. 1

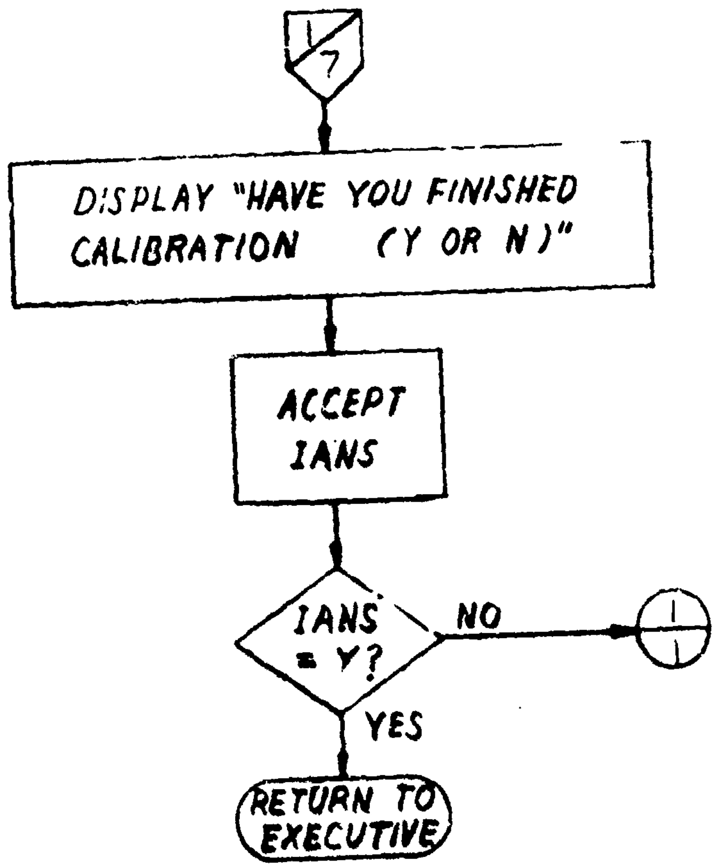
1
7
DISPLAY "HAVE YOU FINISHED
CALIBRATION (Y OR N)"
ACCEPT
IANS
IANS
= Y?
NO
1
1
YES
RETURN TO
EXECUTIVE

FIG. 1

SUBROUTINE SKEW (FREQ, SK)

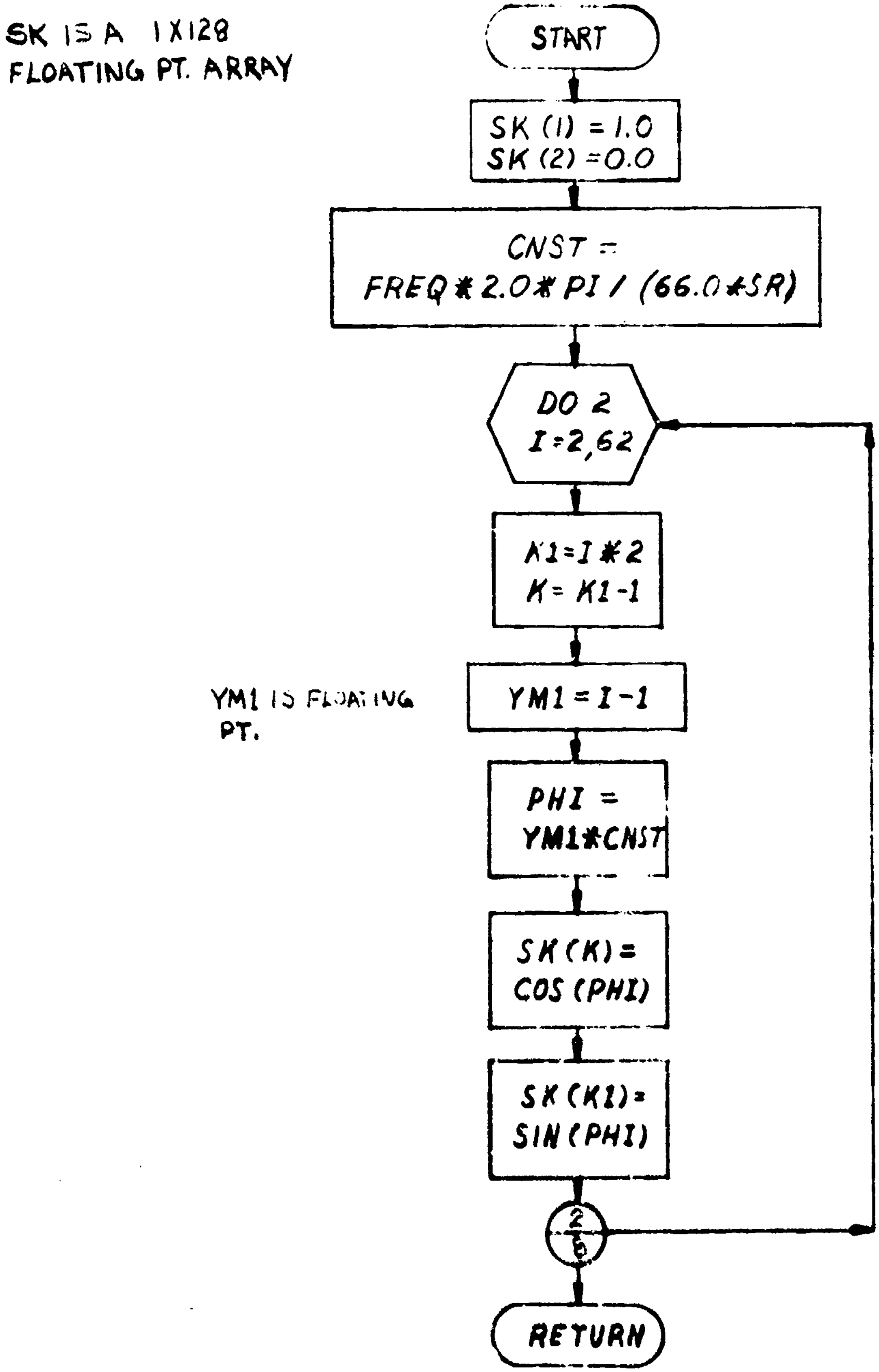

FIG 2

SUBROUTINE MATX(A, B, C)

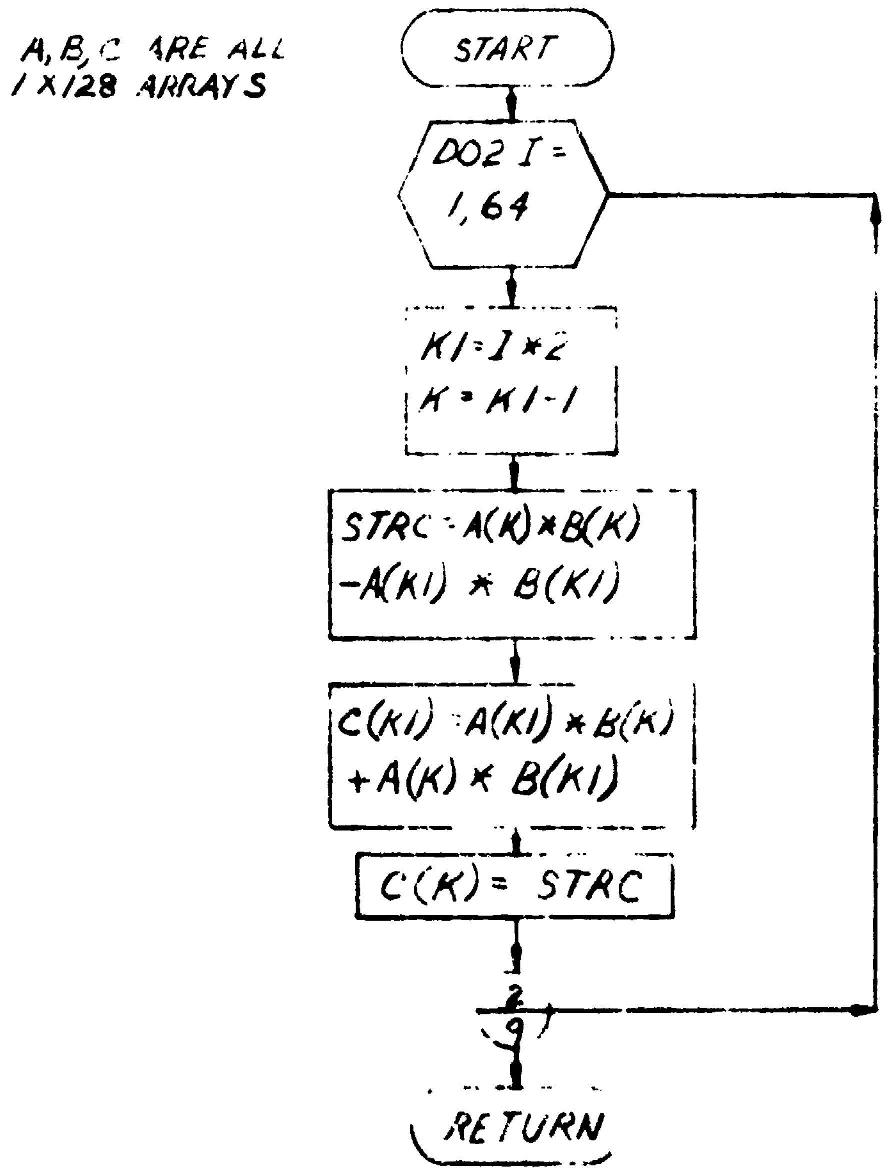

FIG 5

SUBROUTINE CNVRT(X,Y,AMP,PHASE)

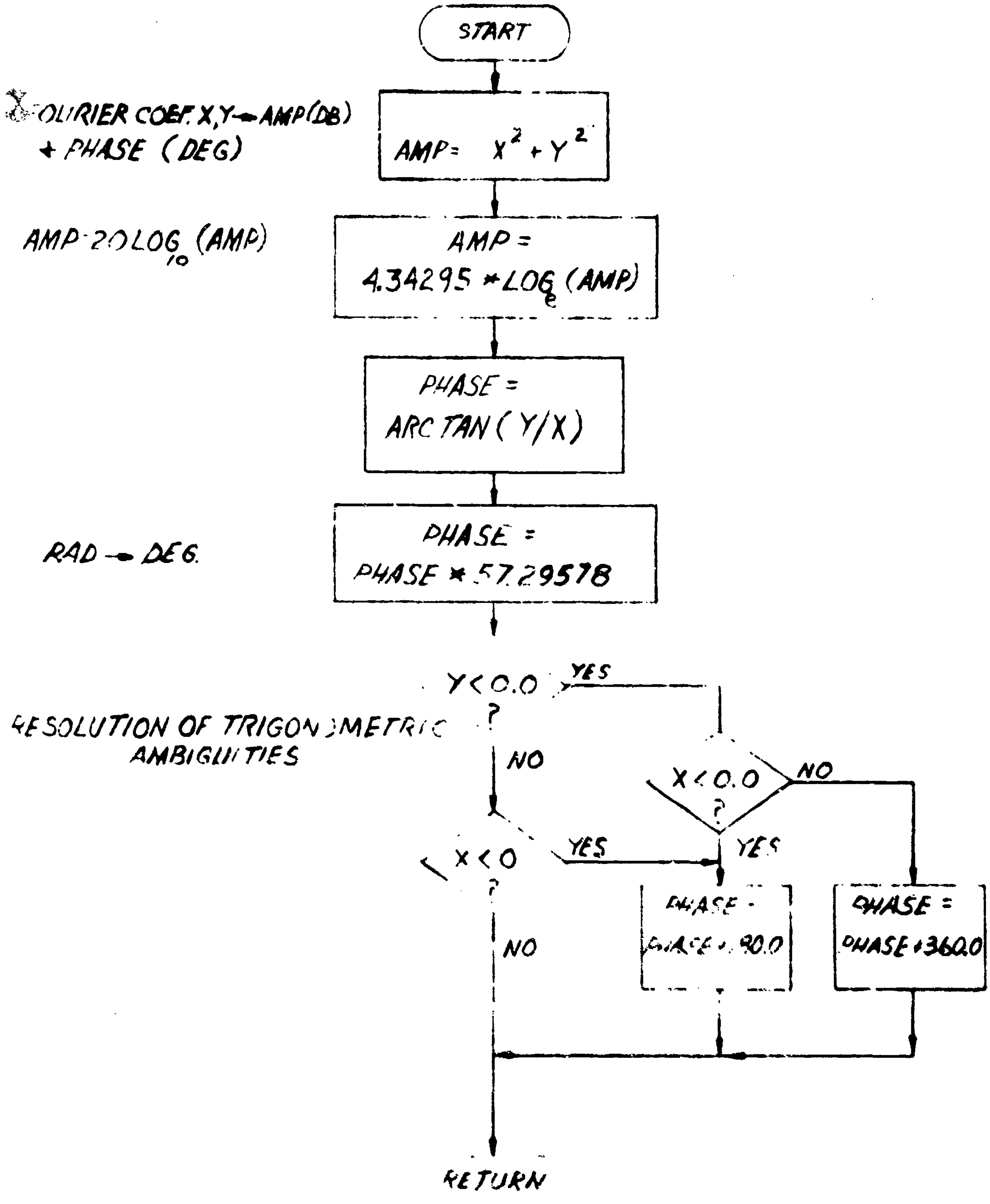

FIG 4

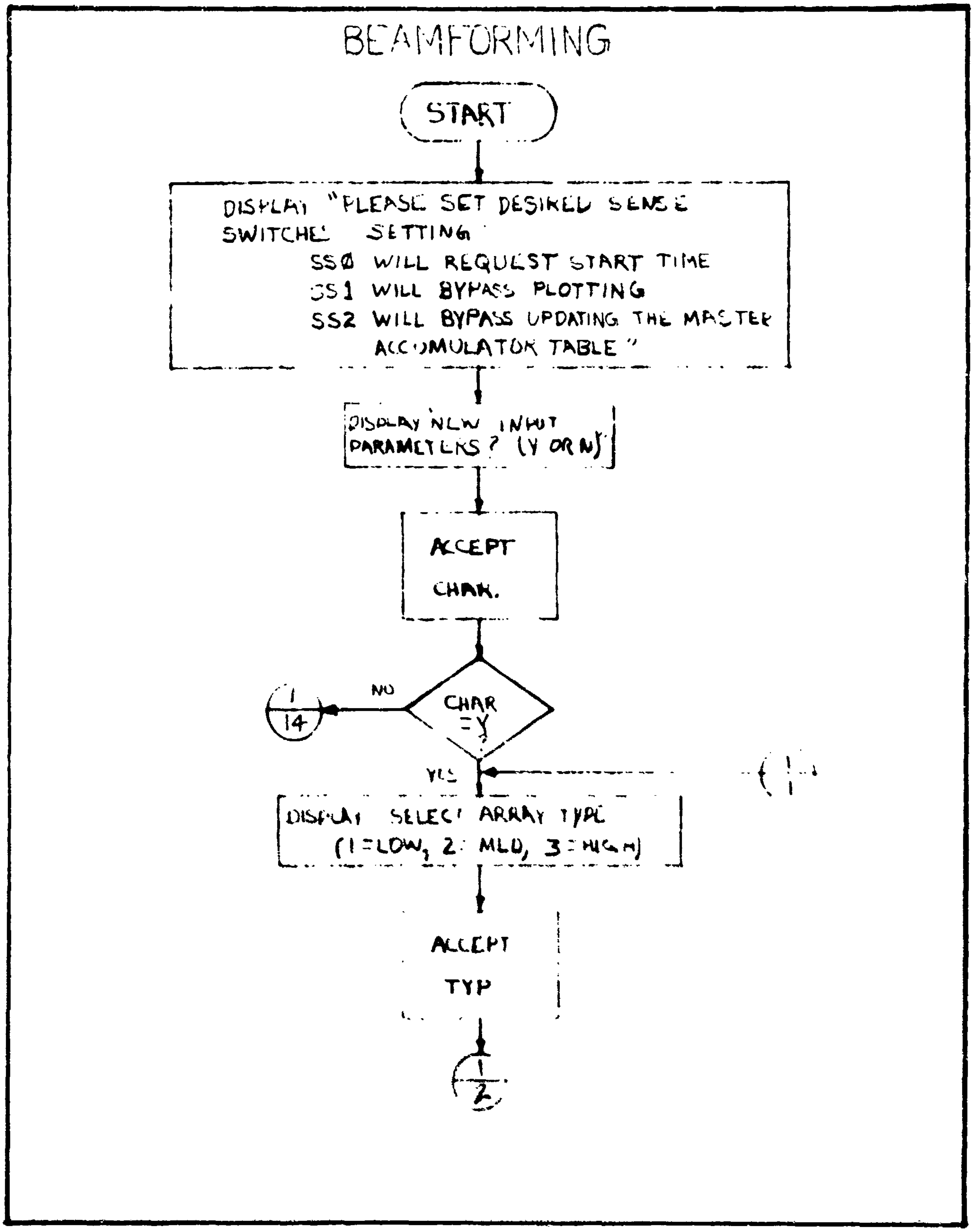

Figure 5 : BEAMFORMING **Page 1 of 22**

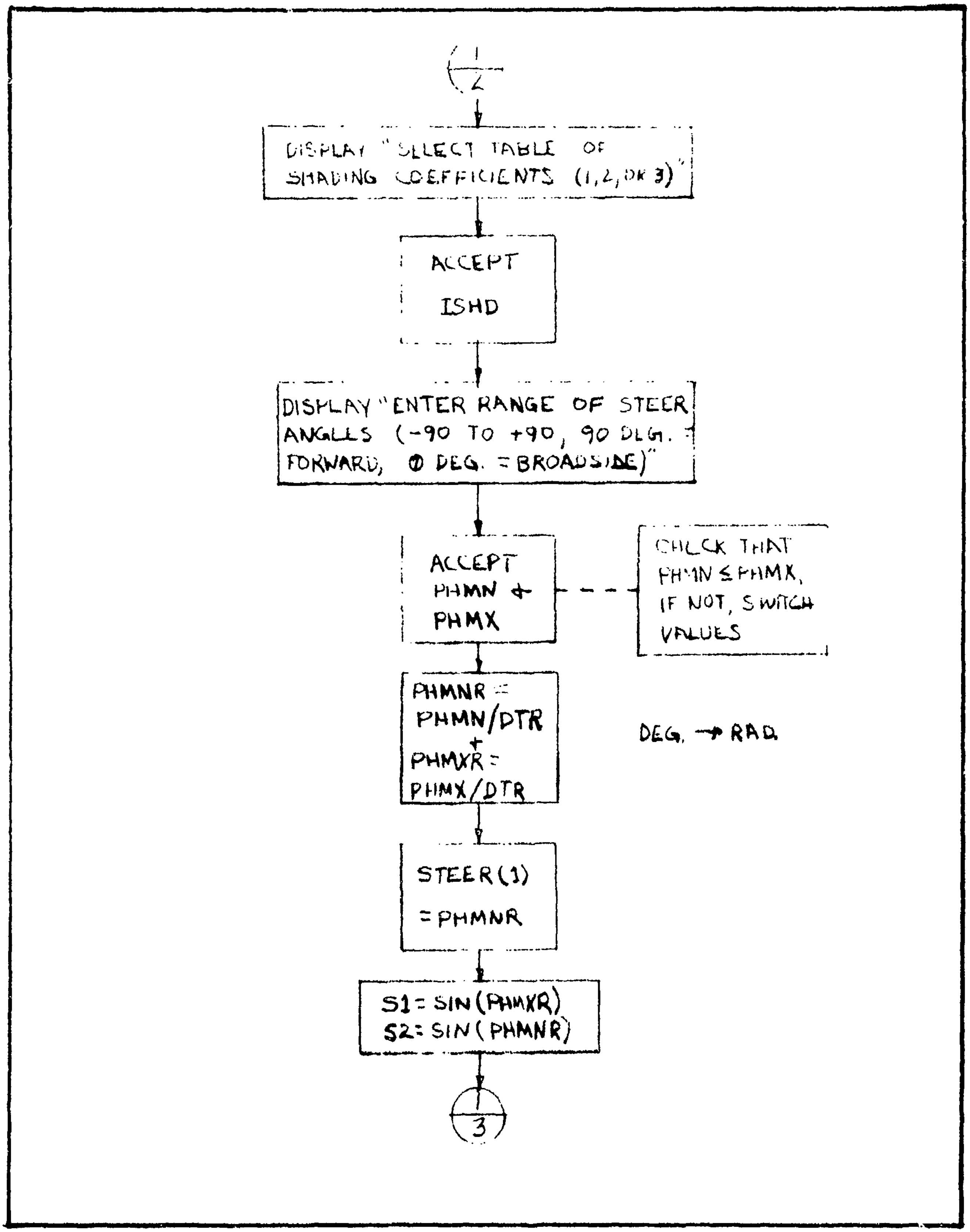

Figure 5 : BEAMFORMING

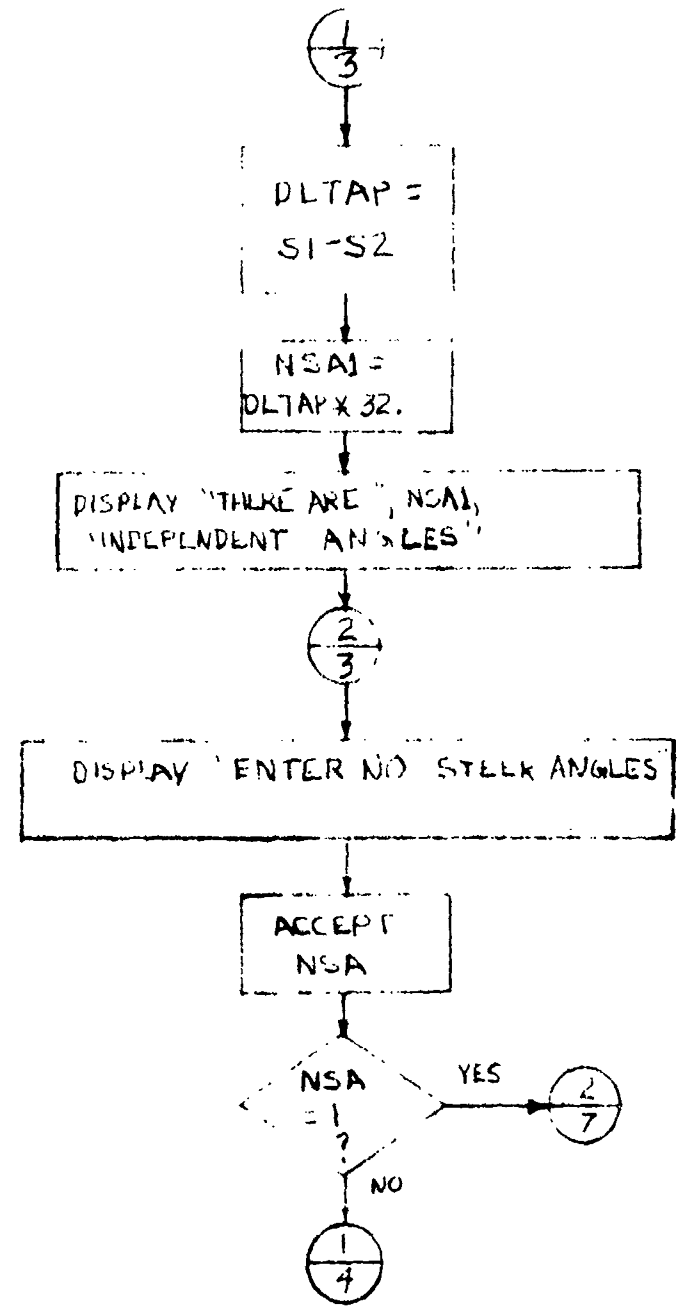

Figure 5 : BEAMFORMING **Page 3 of __**

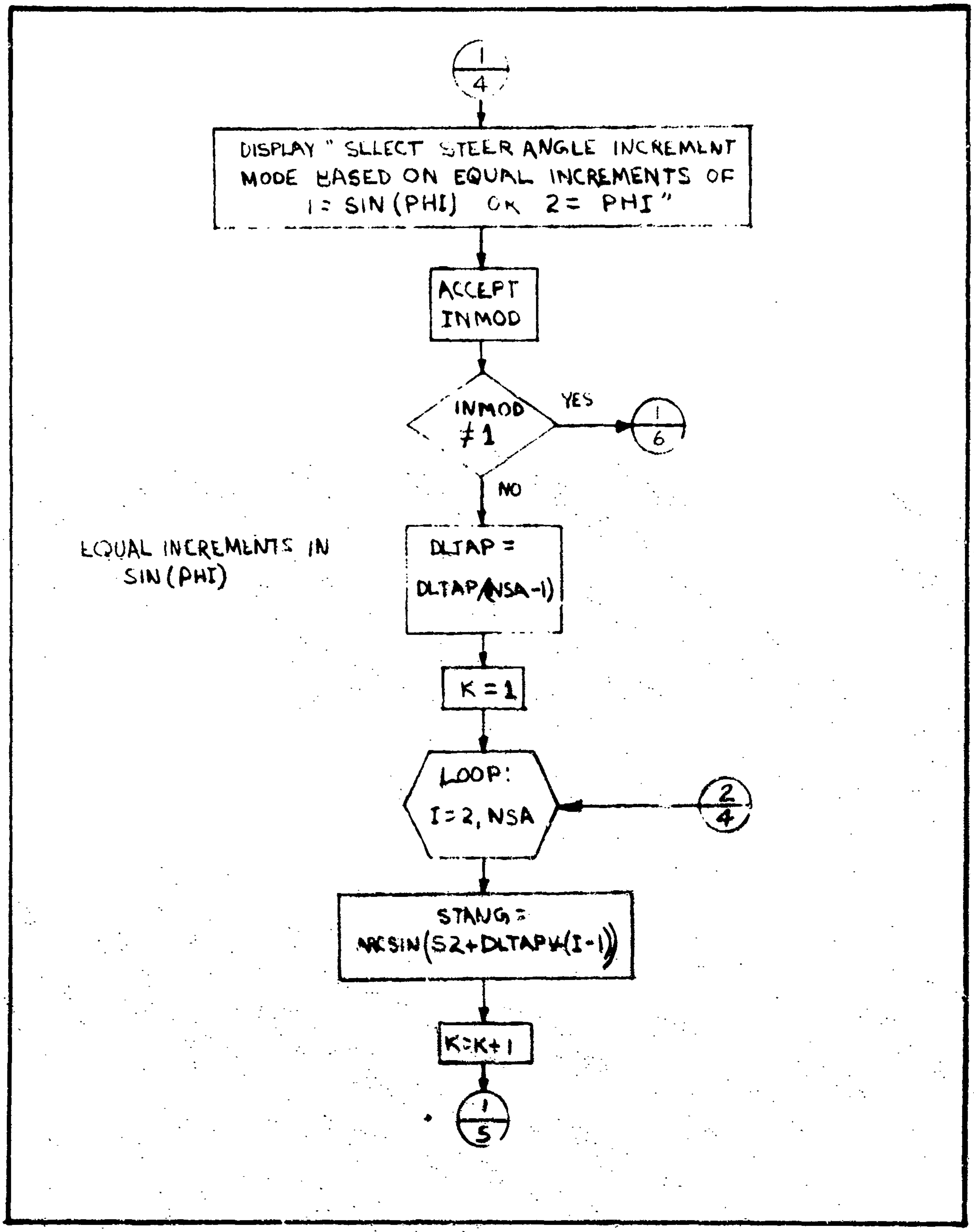

Figure 5 : BEAMFORMING

Page 4 of

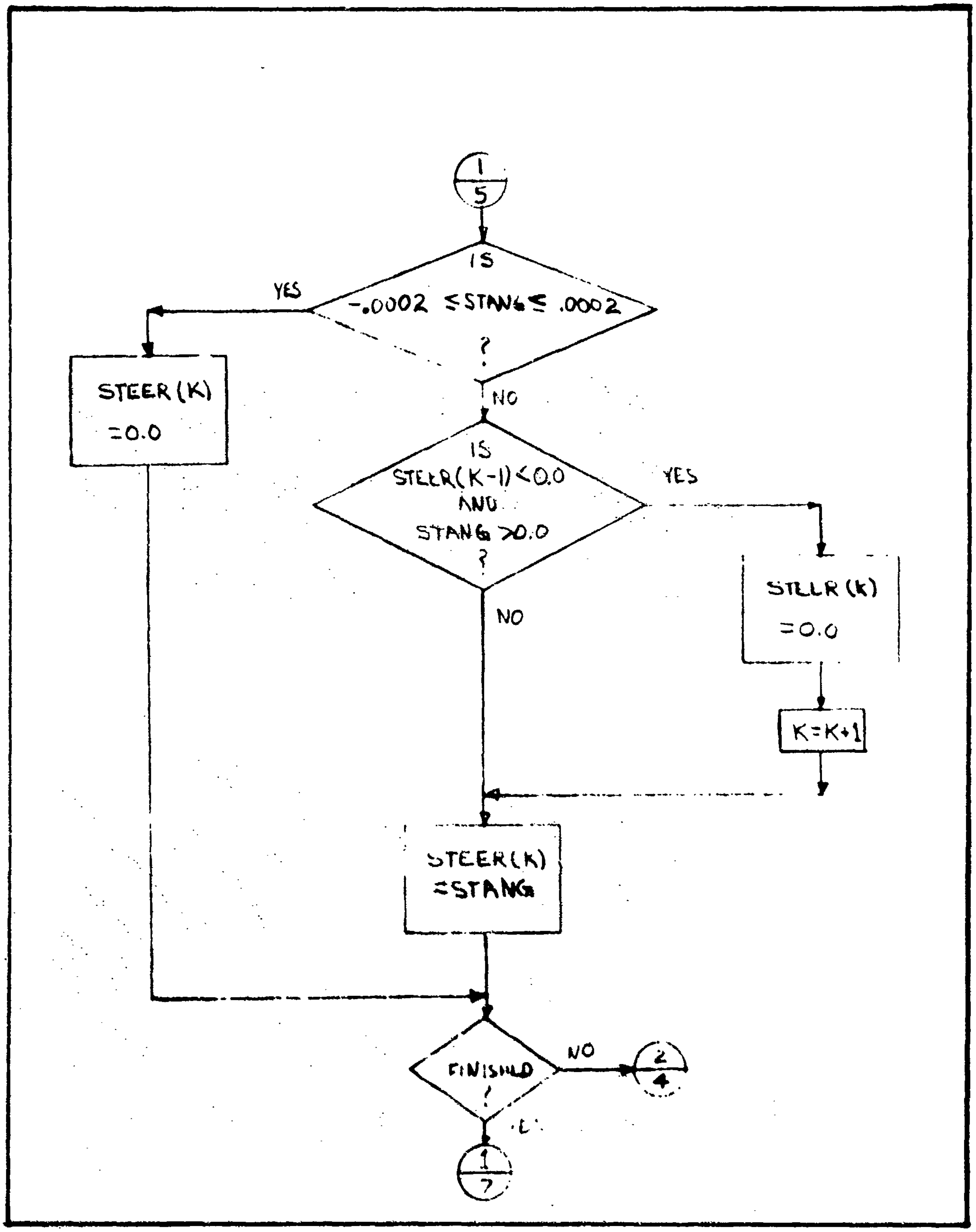

Figure 5 :BEAMFORMING

Page 5 of 22

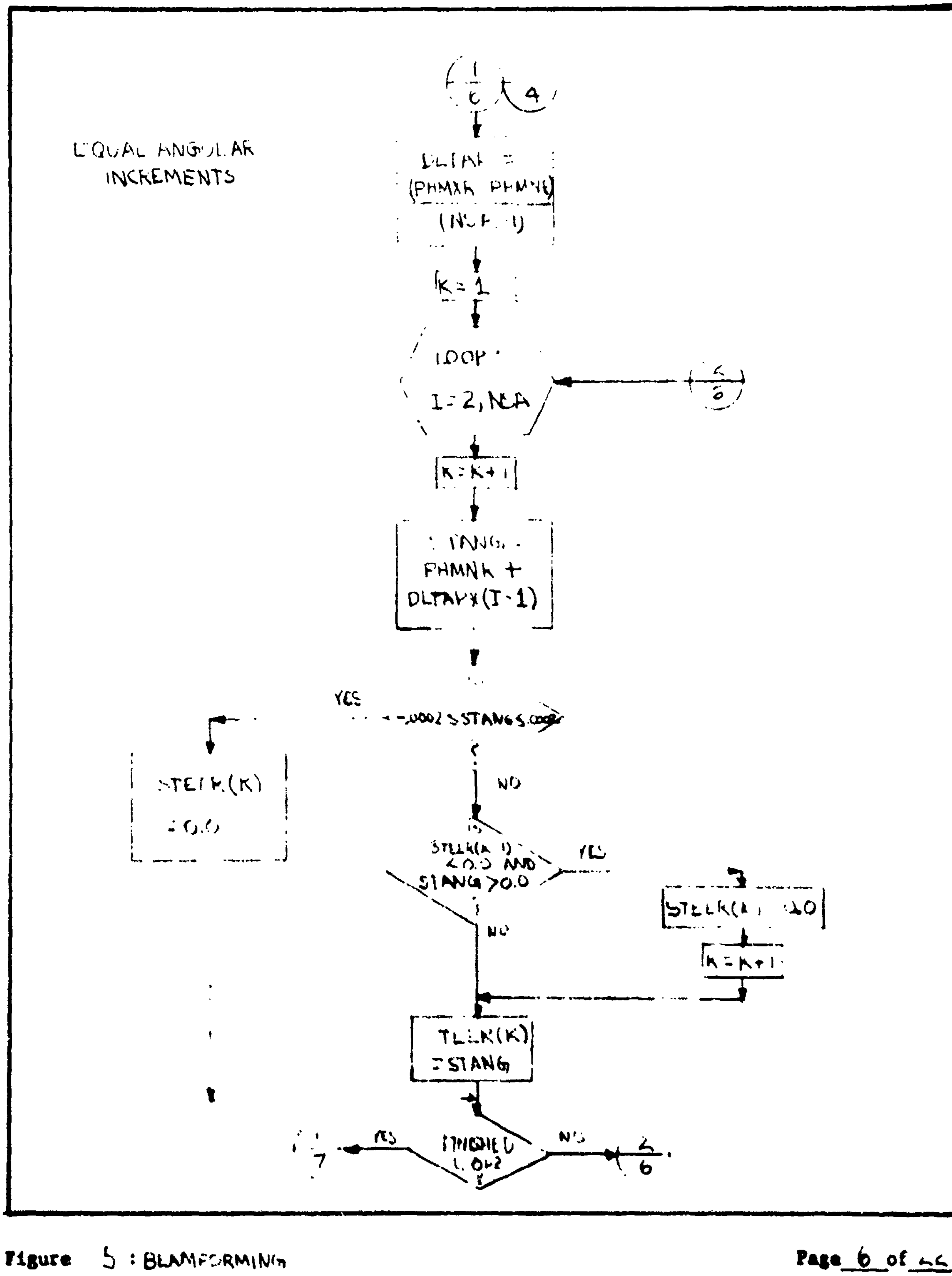

Figure 5 : BEAMFORMING

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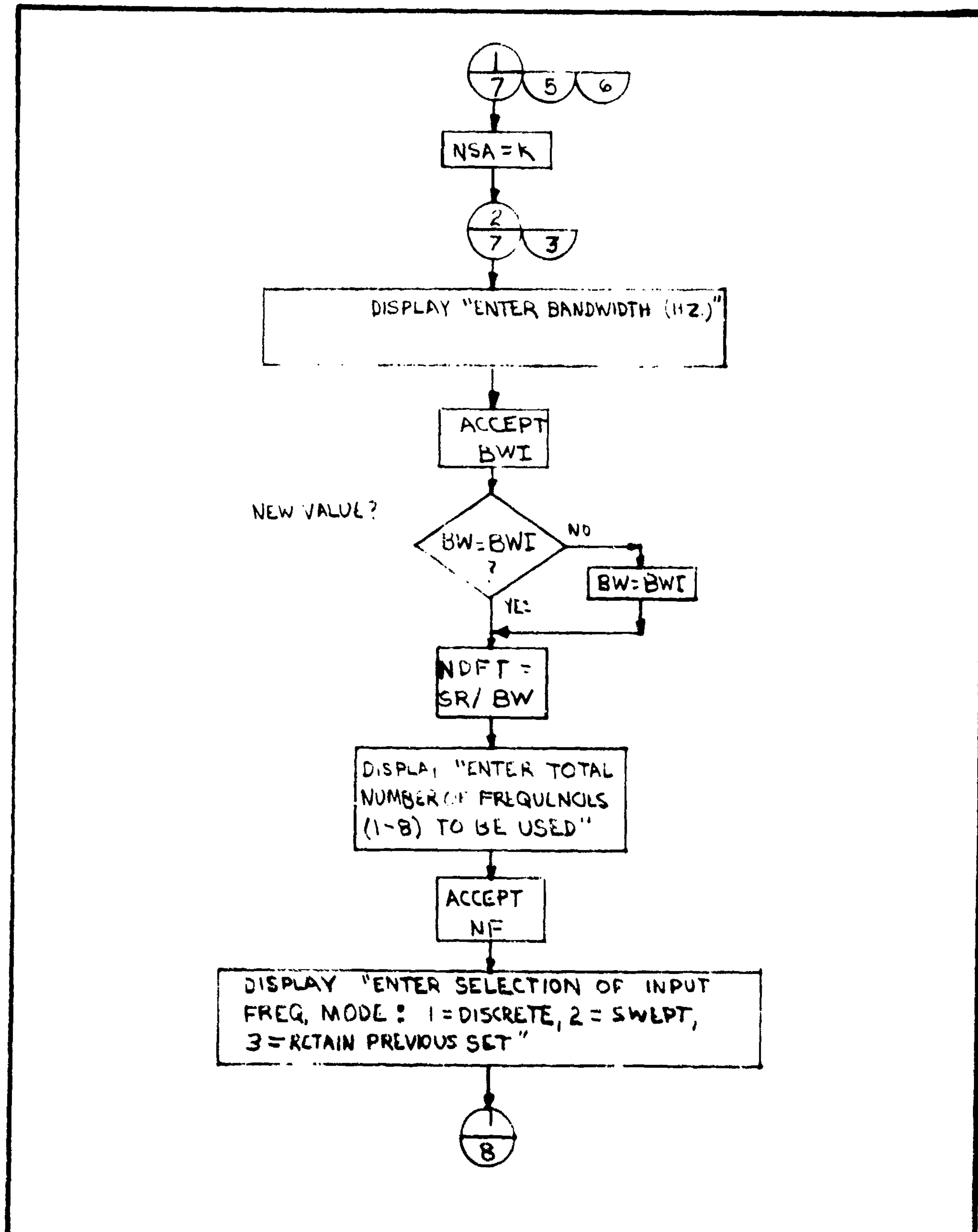

Figure 5 : BEAMFORMING

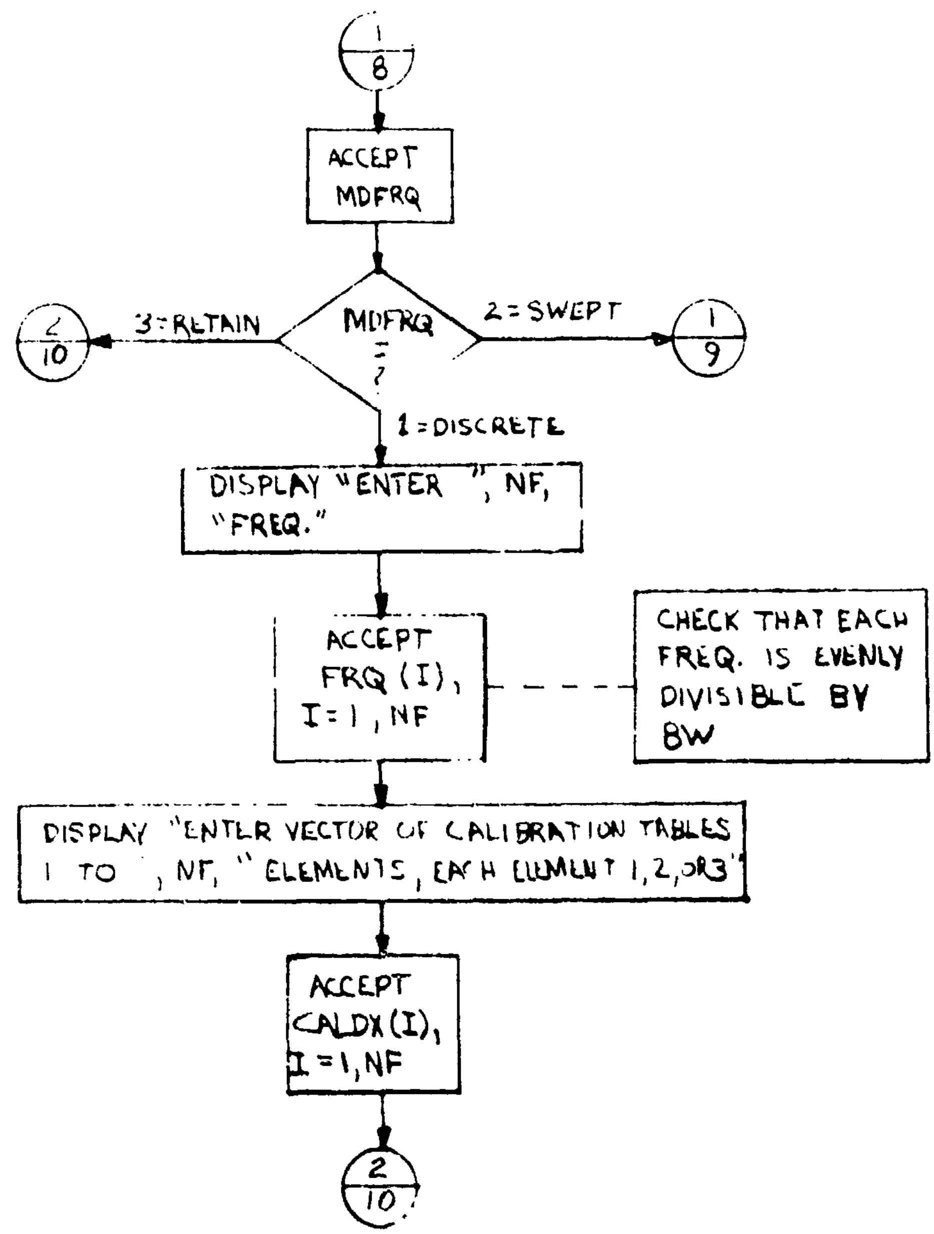

Figure 5 : BEAMFORMING

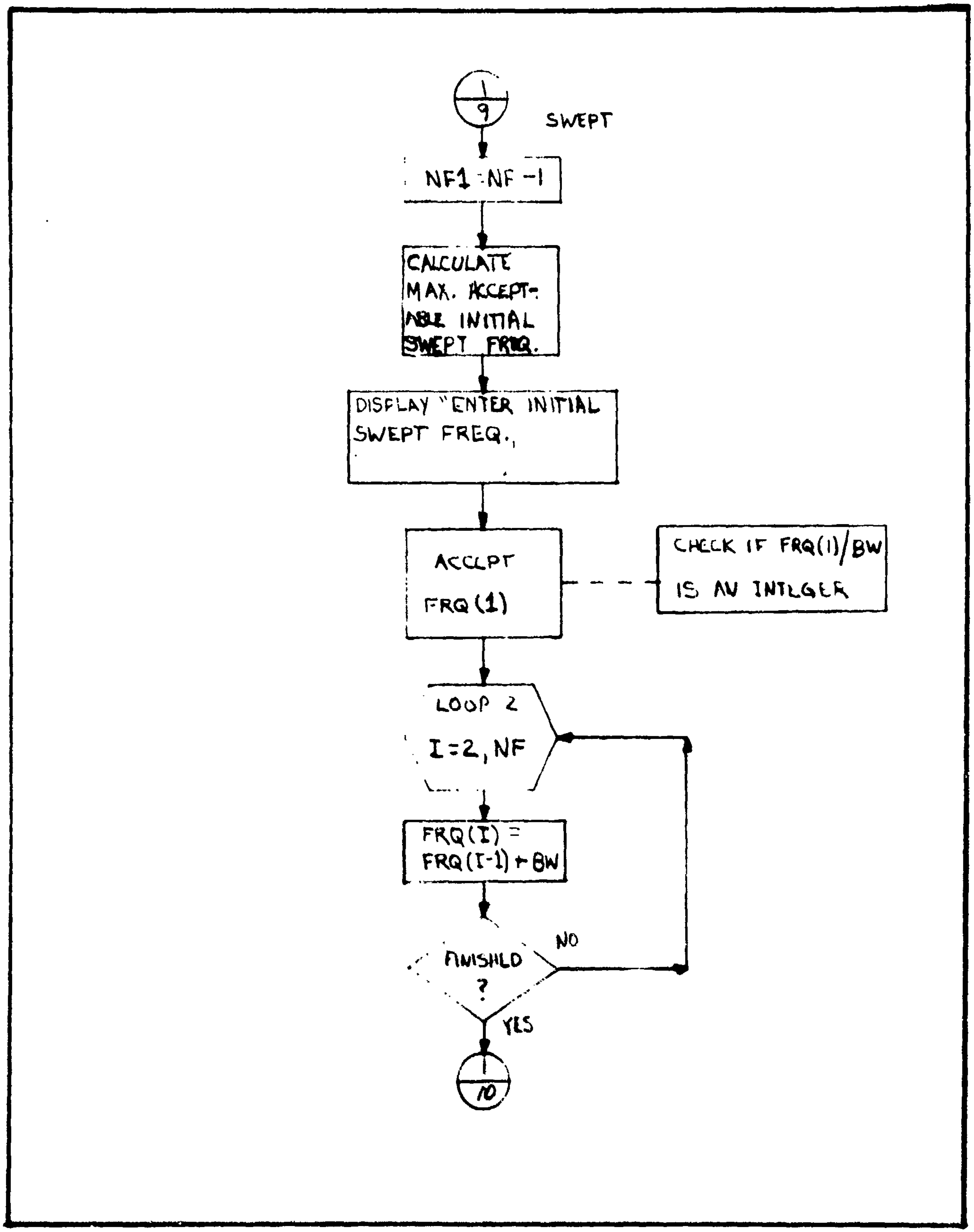

Figure 5 : BEAMFORMING

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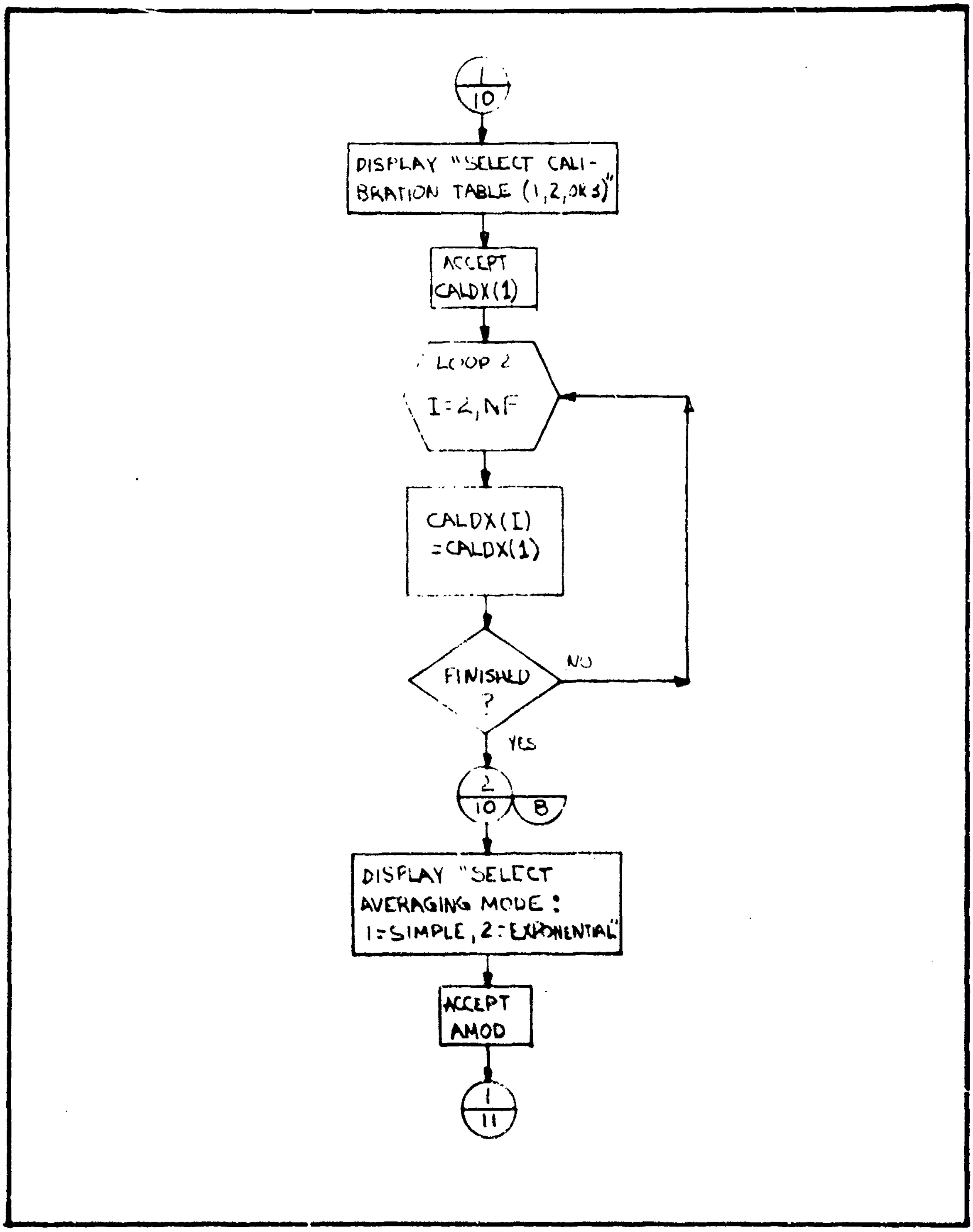

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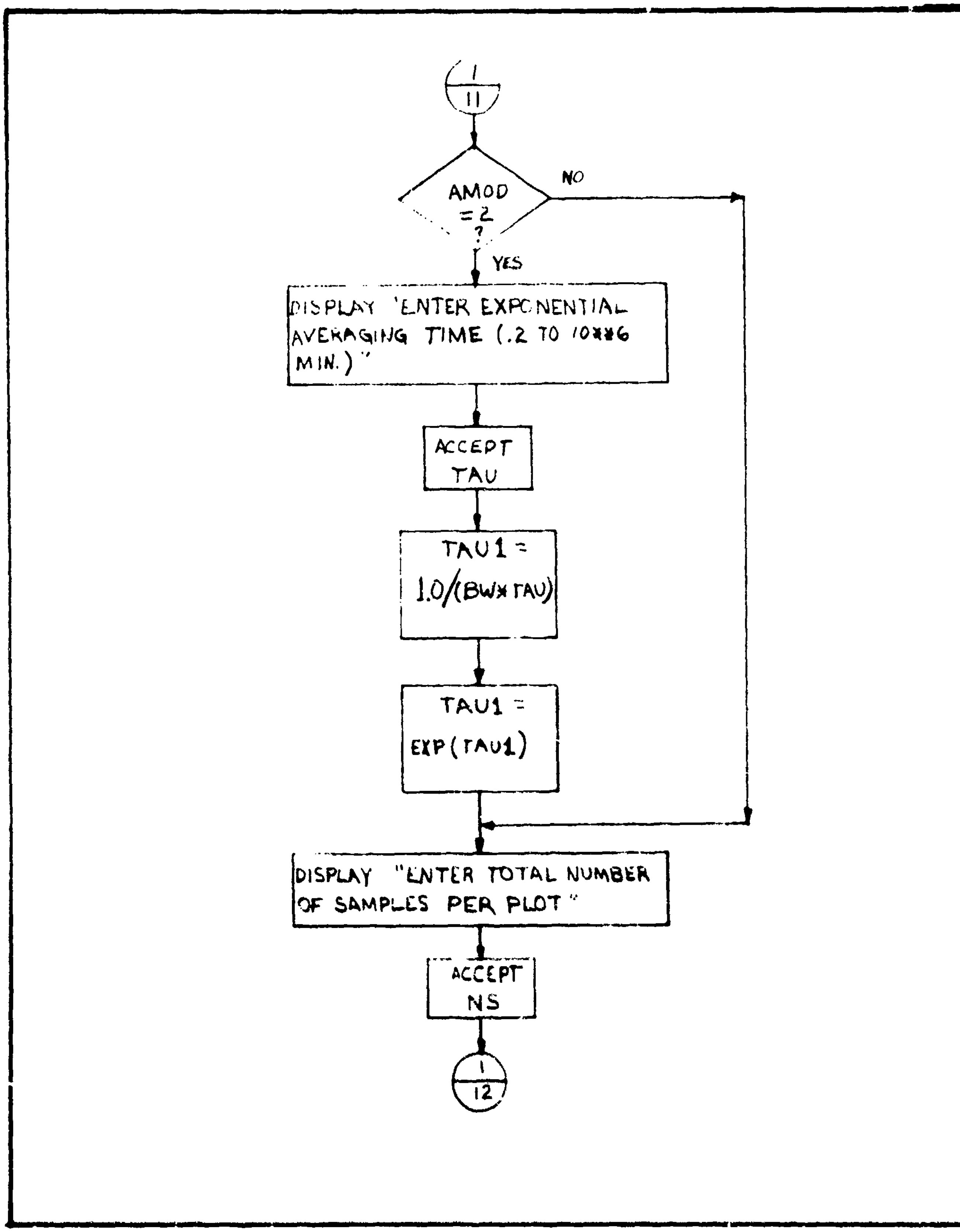

Figure 5 : BEAMFORMING

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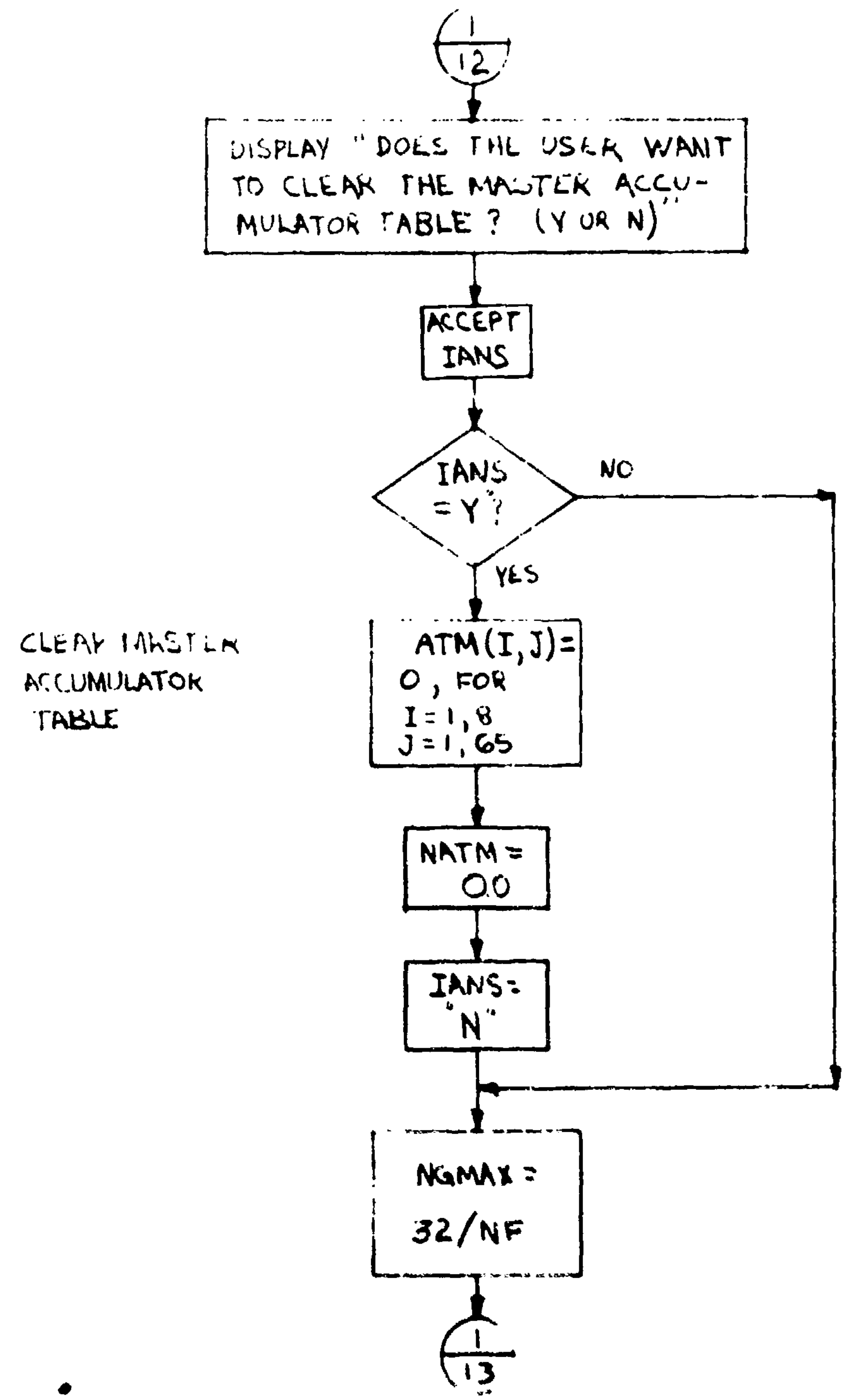

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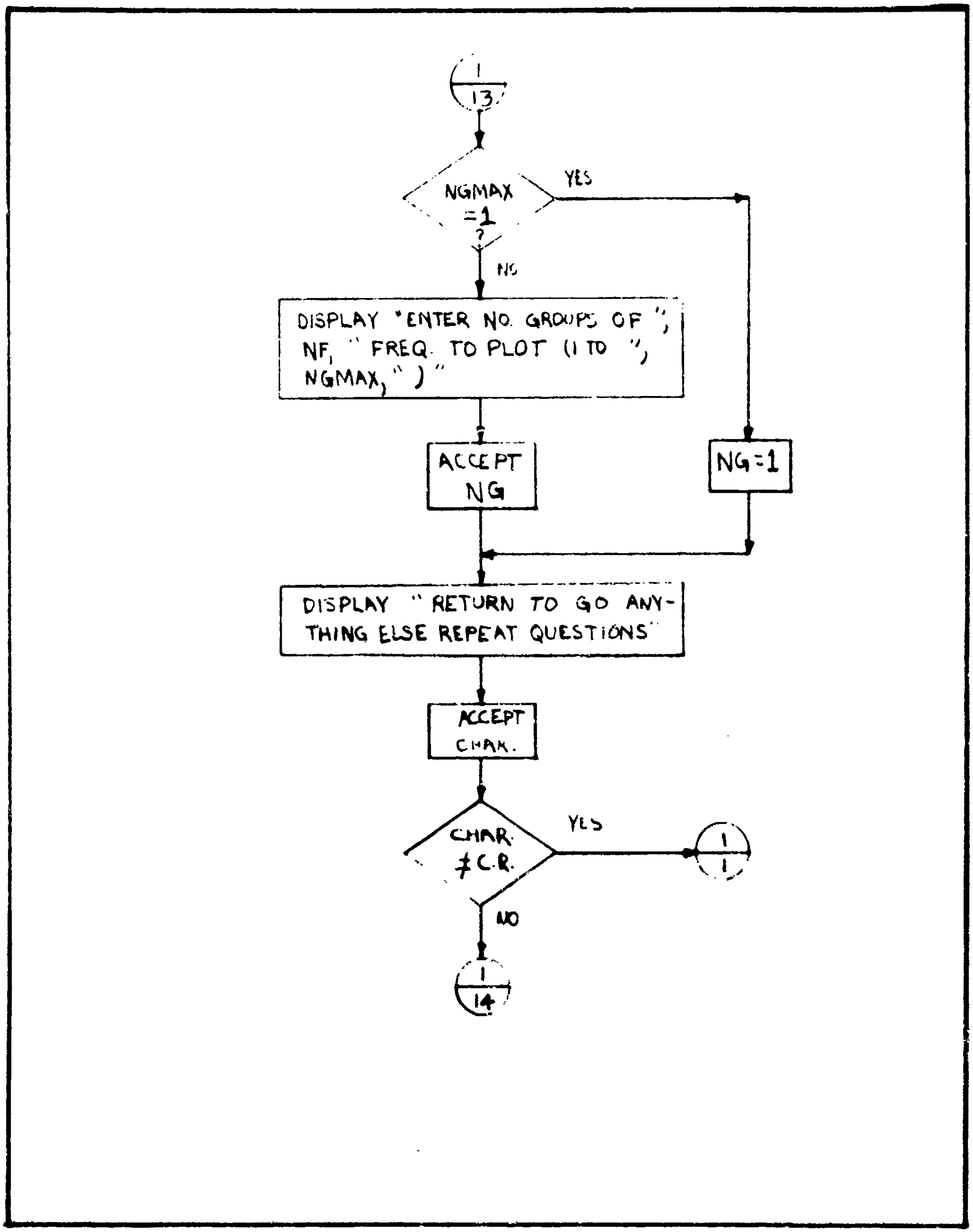

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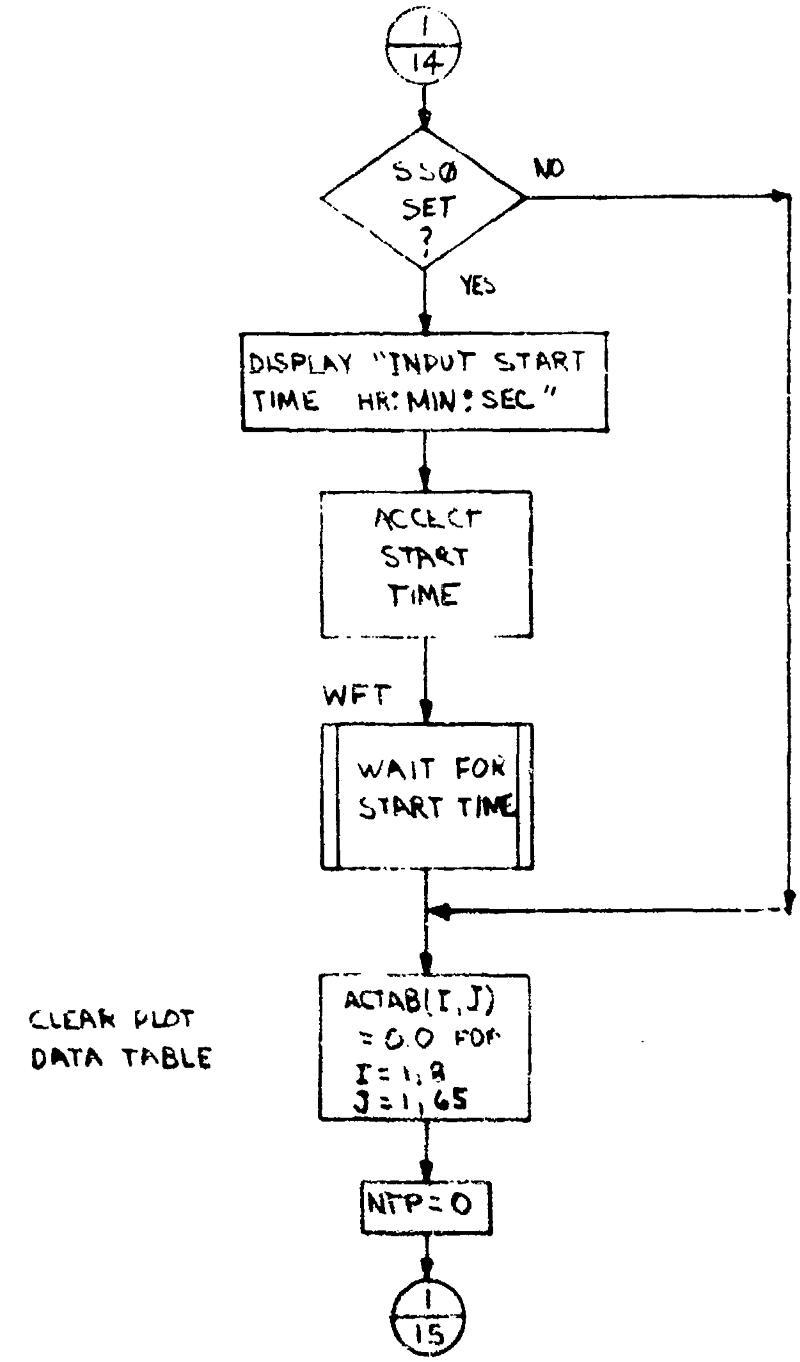

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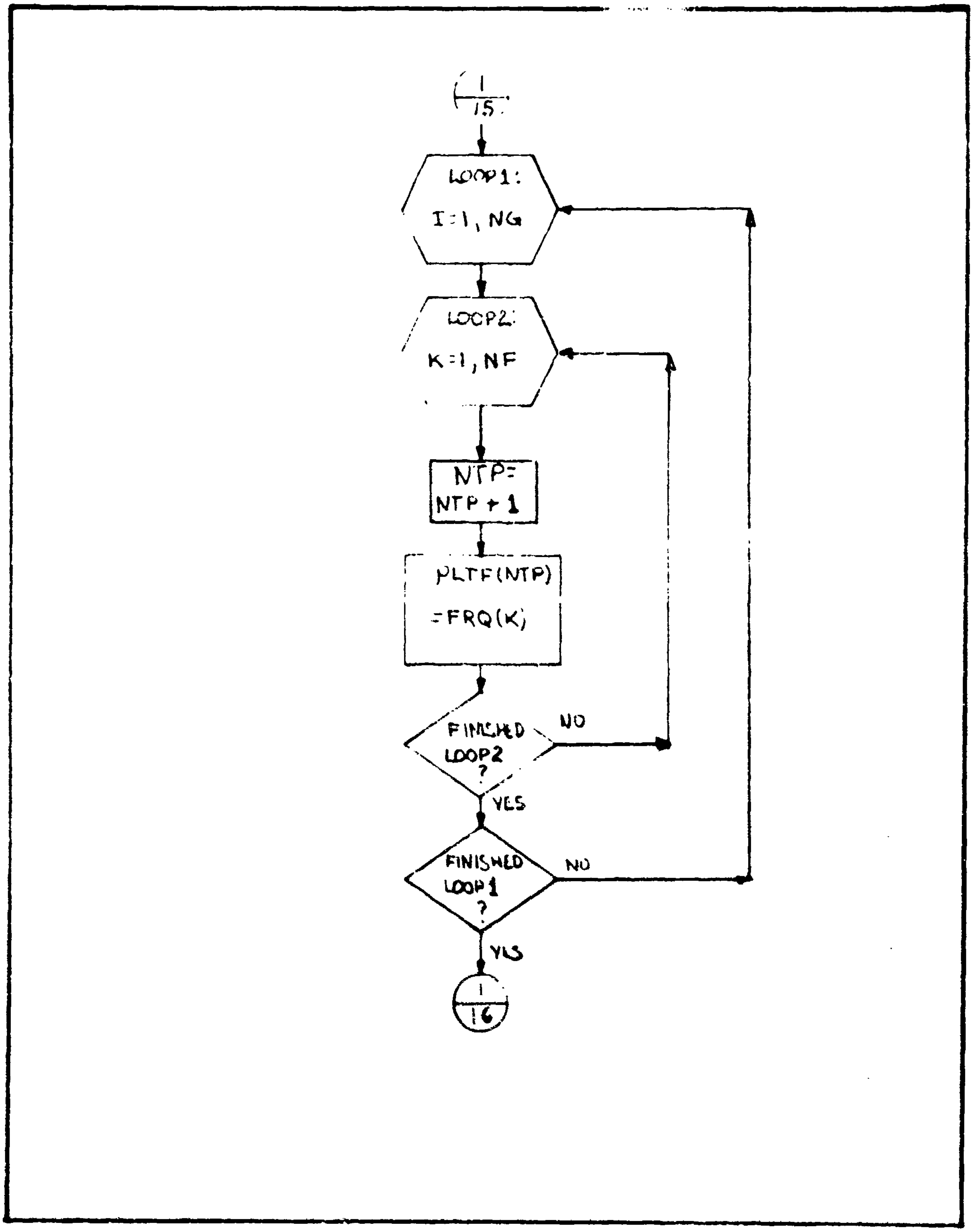

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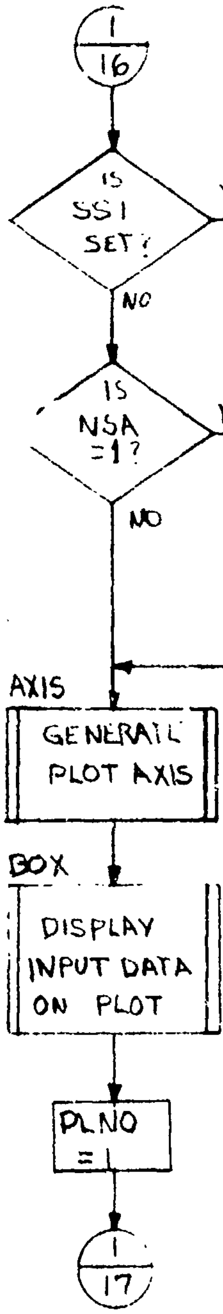

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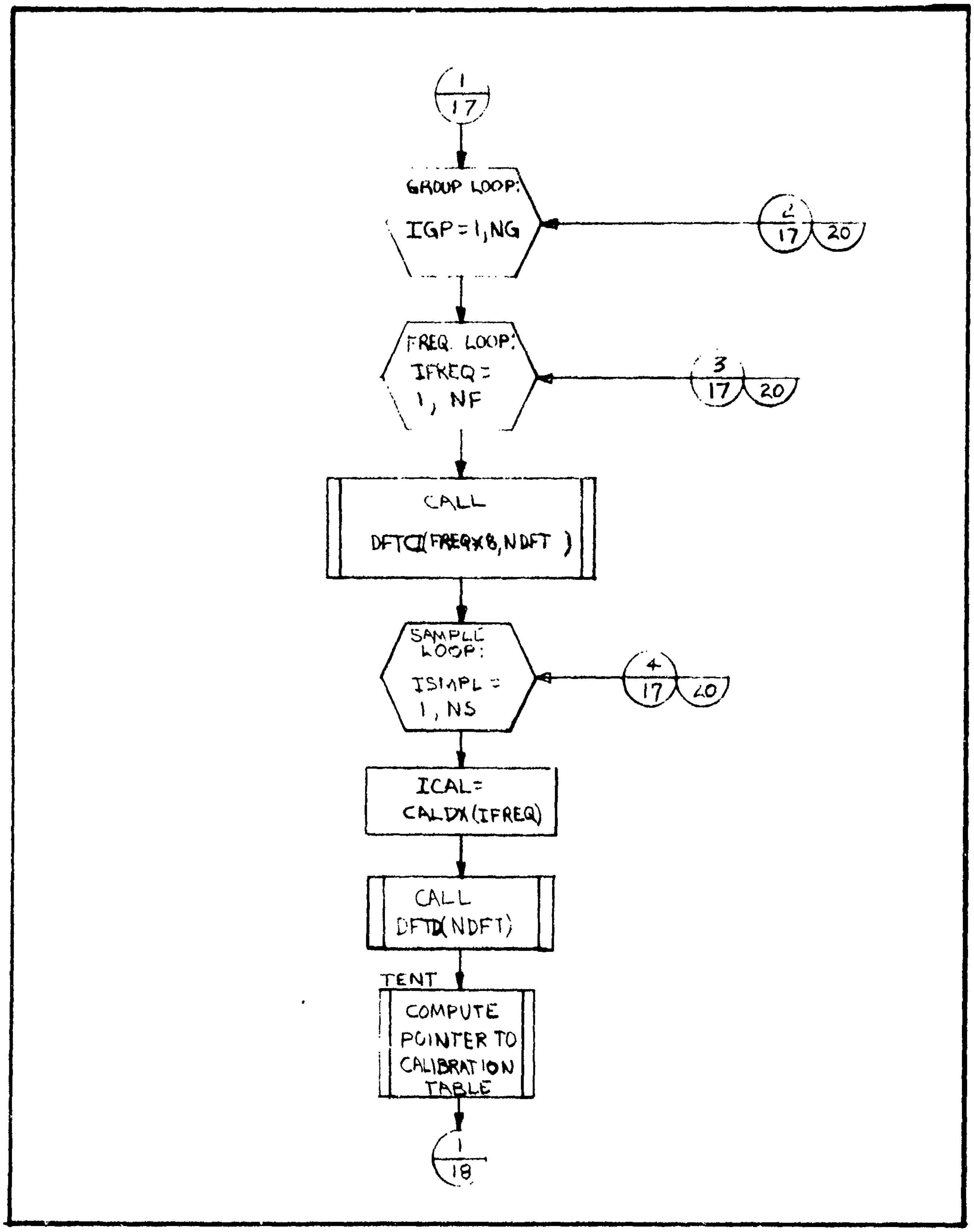

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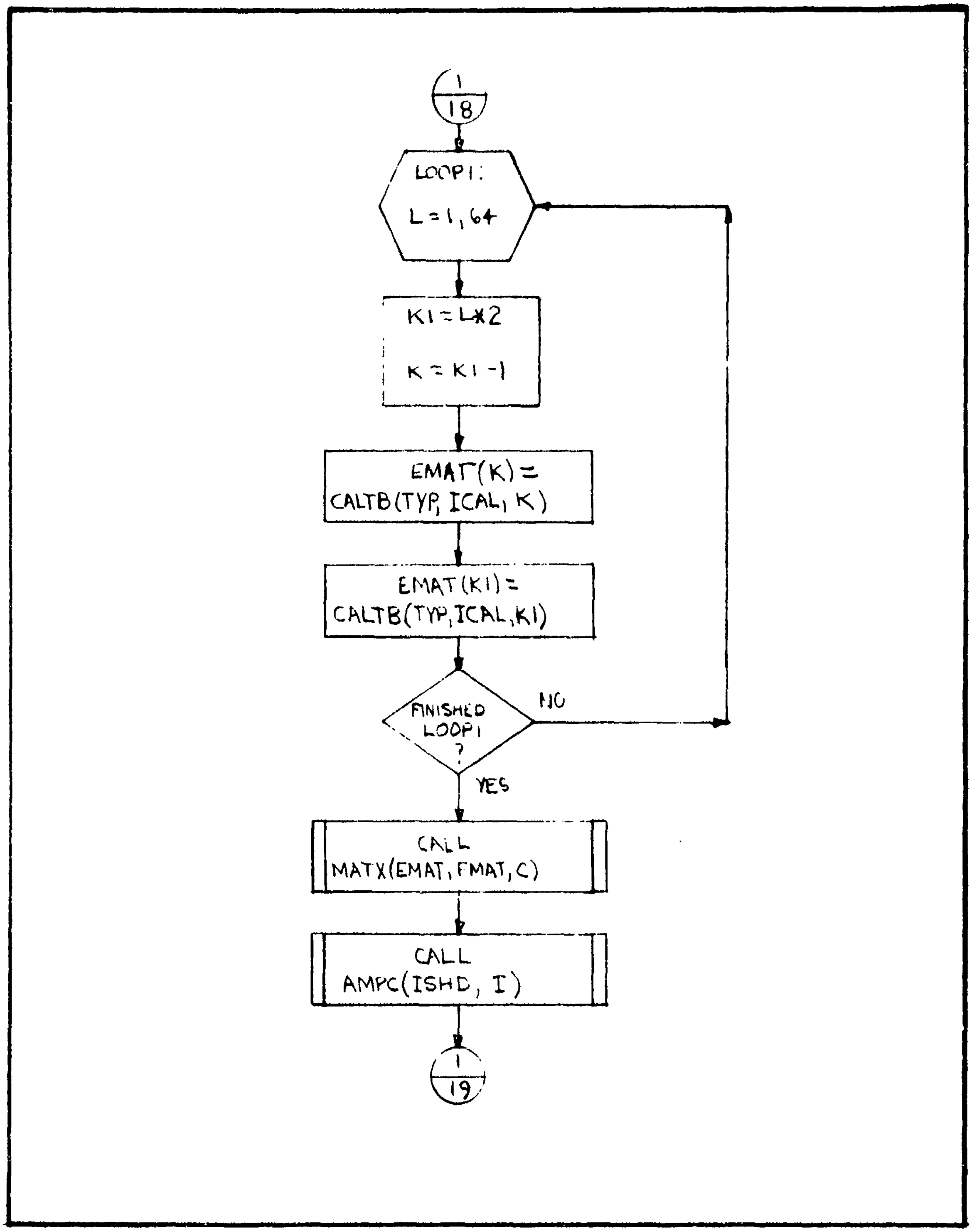

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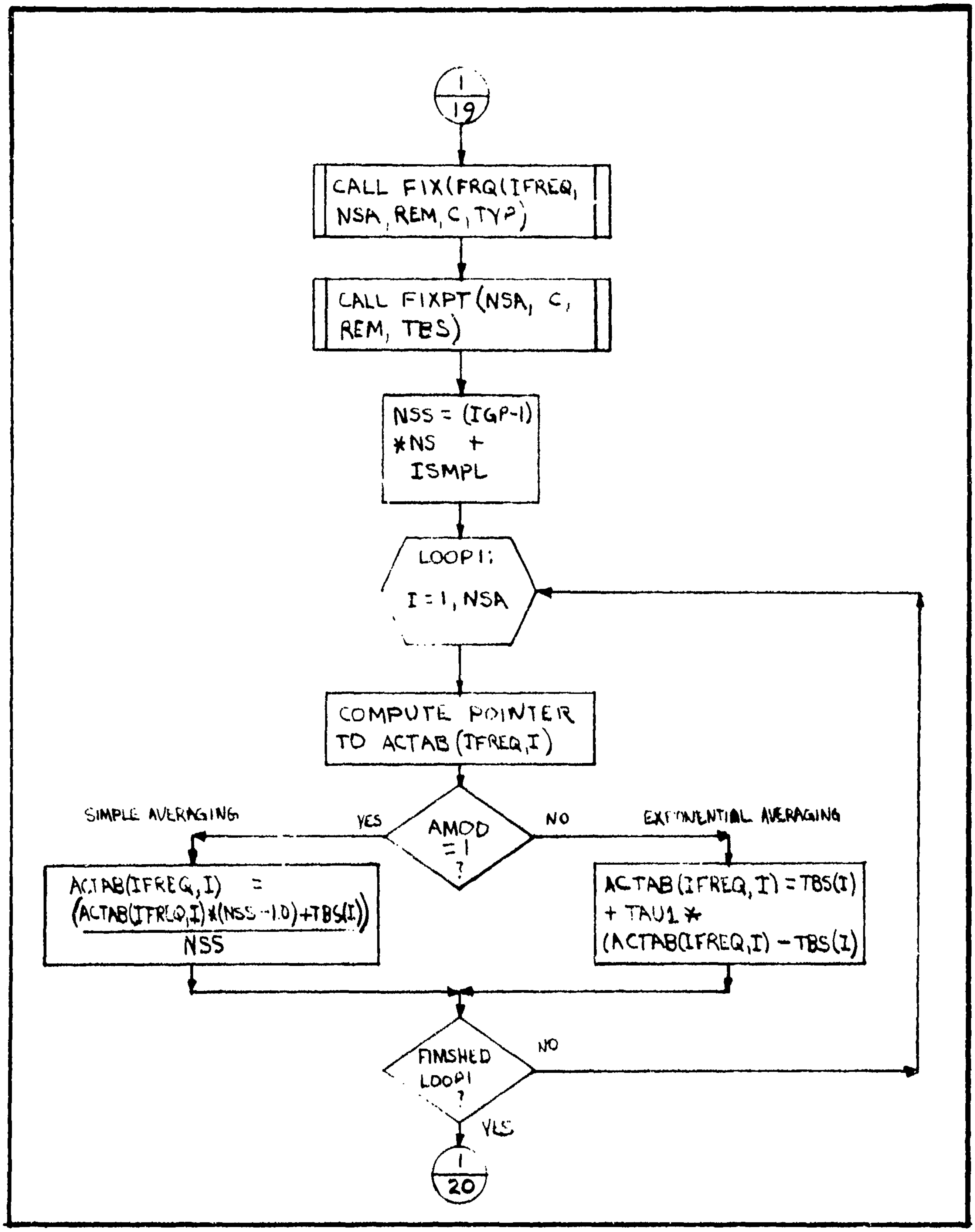

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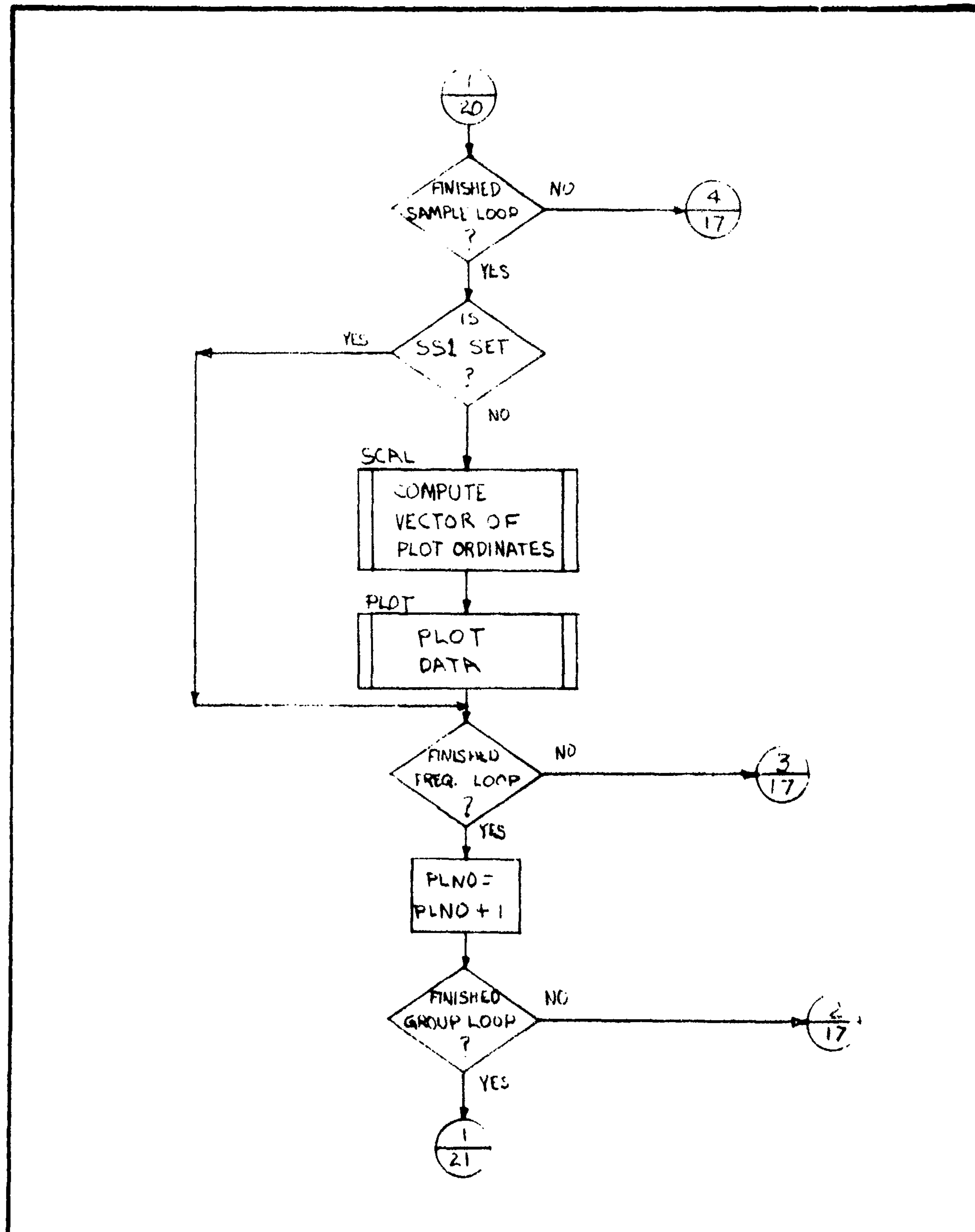

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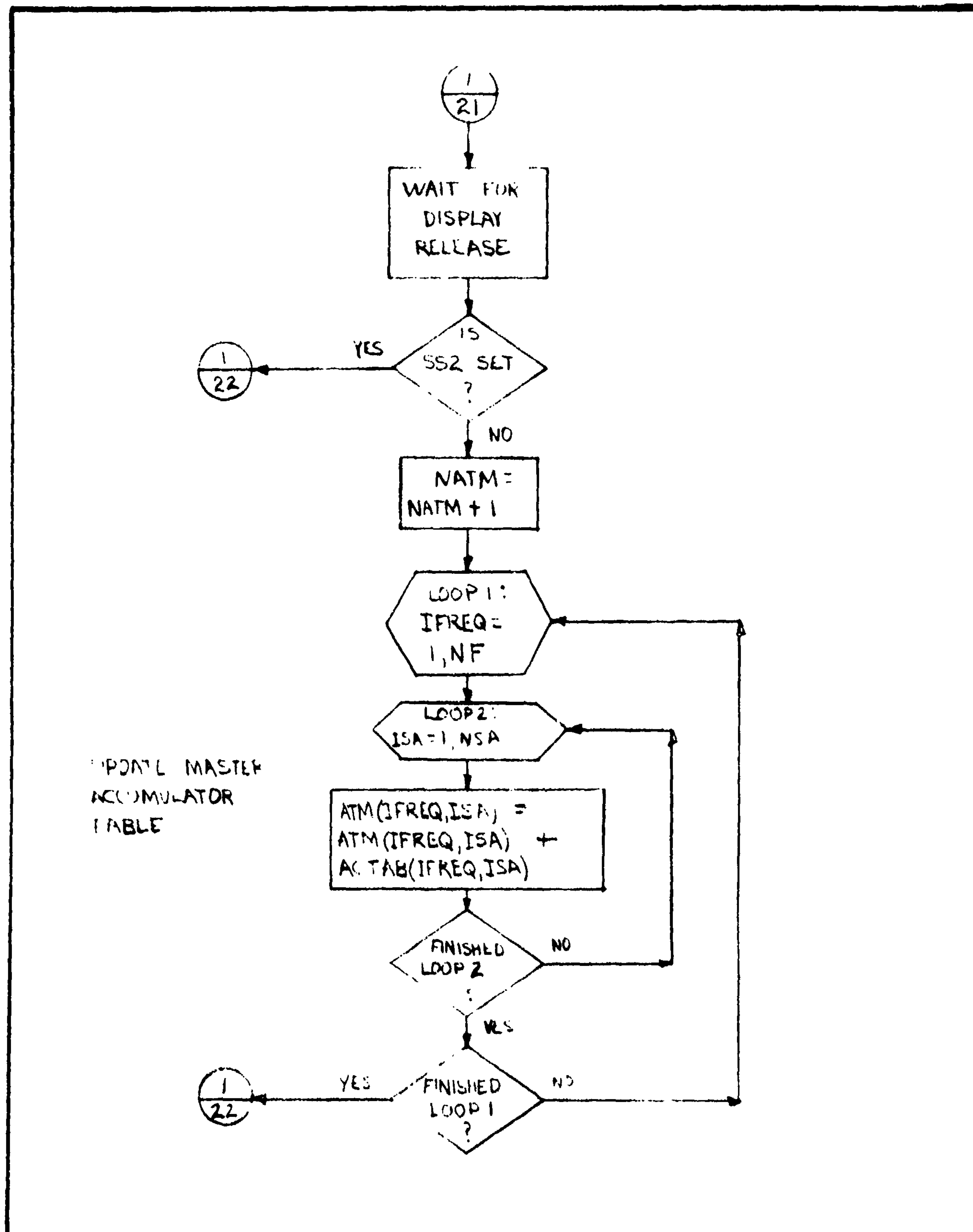

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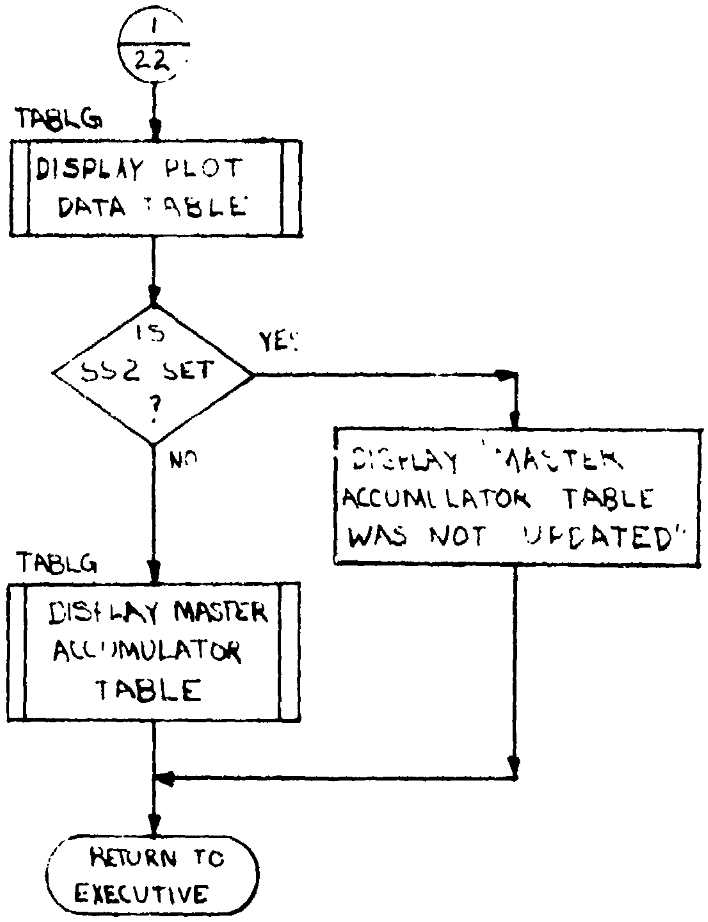

Figure 5 : BEAMFORMING

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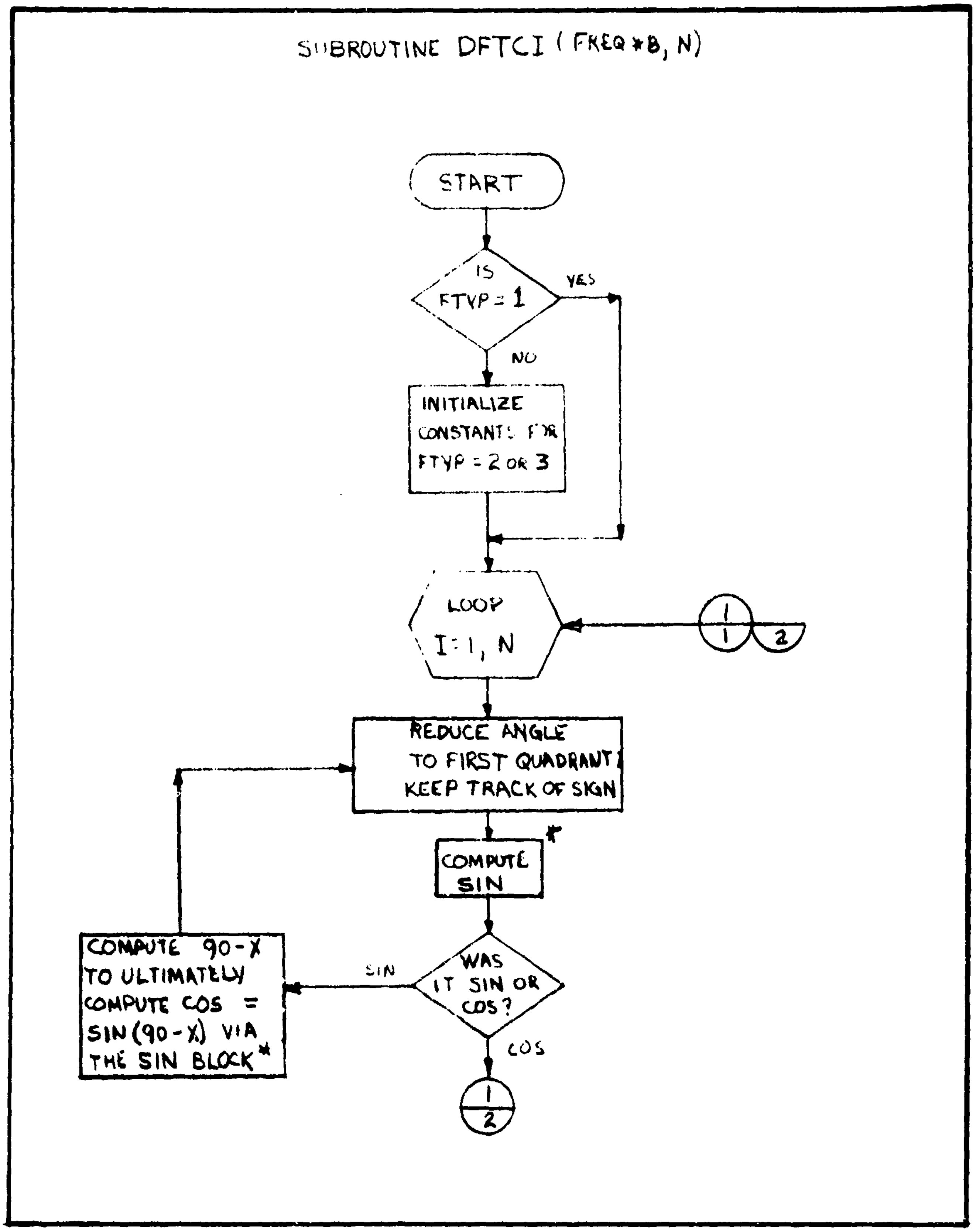

Figure 6 : SUBROUTINE DFTCI

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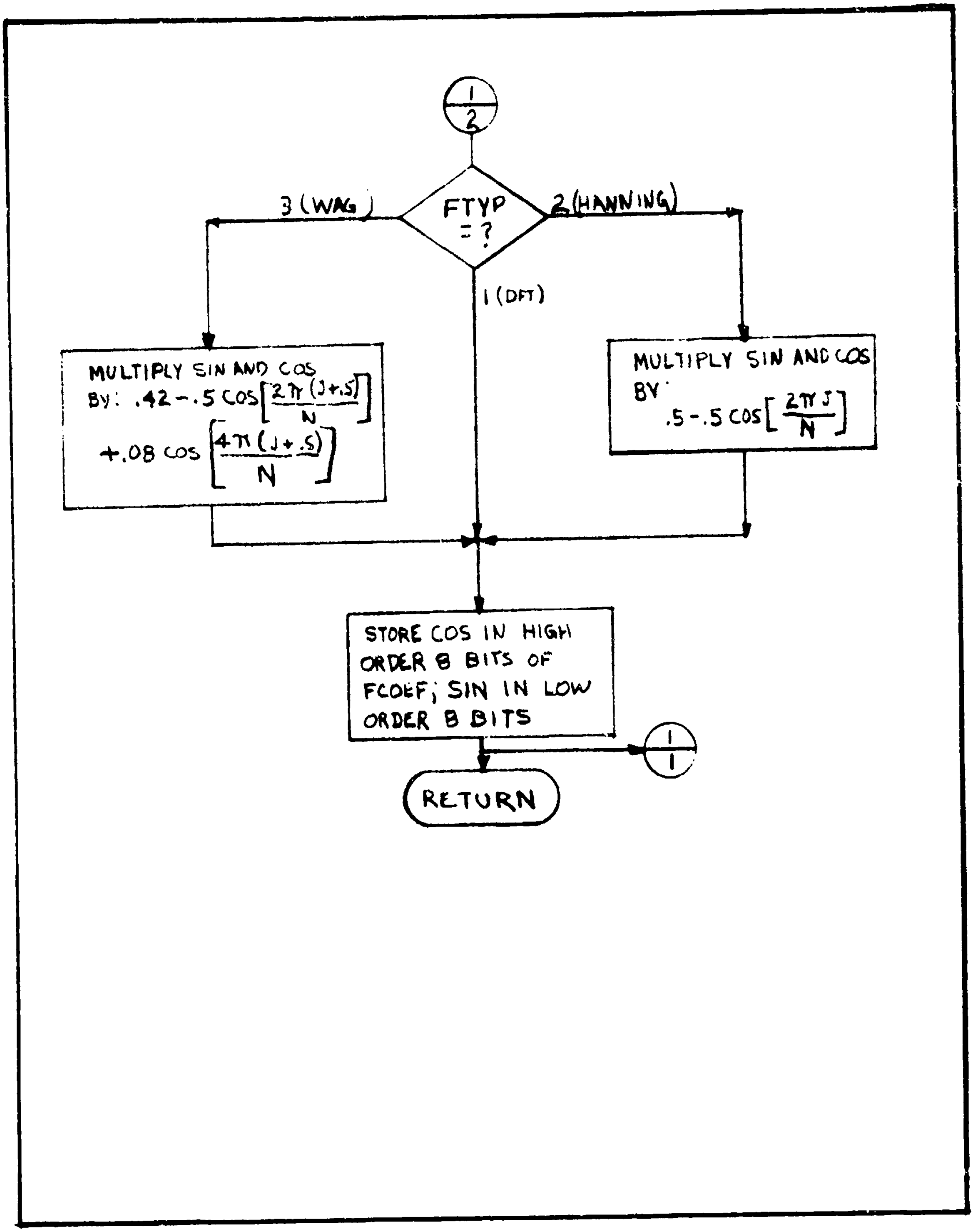

Figure 6 : SUBROUTINE DFTCI

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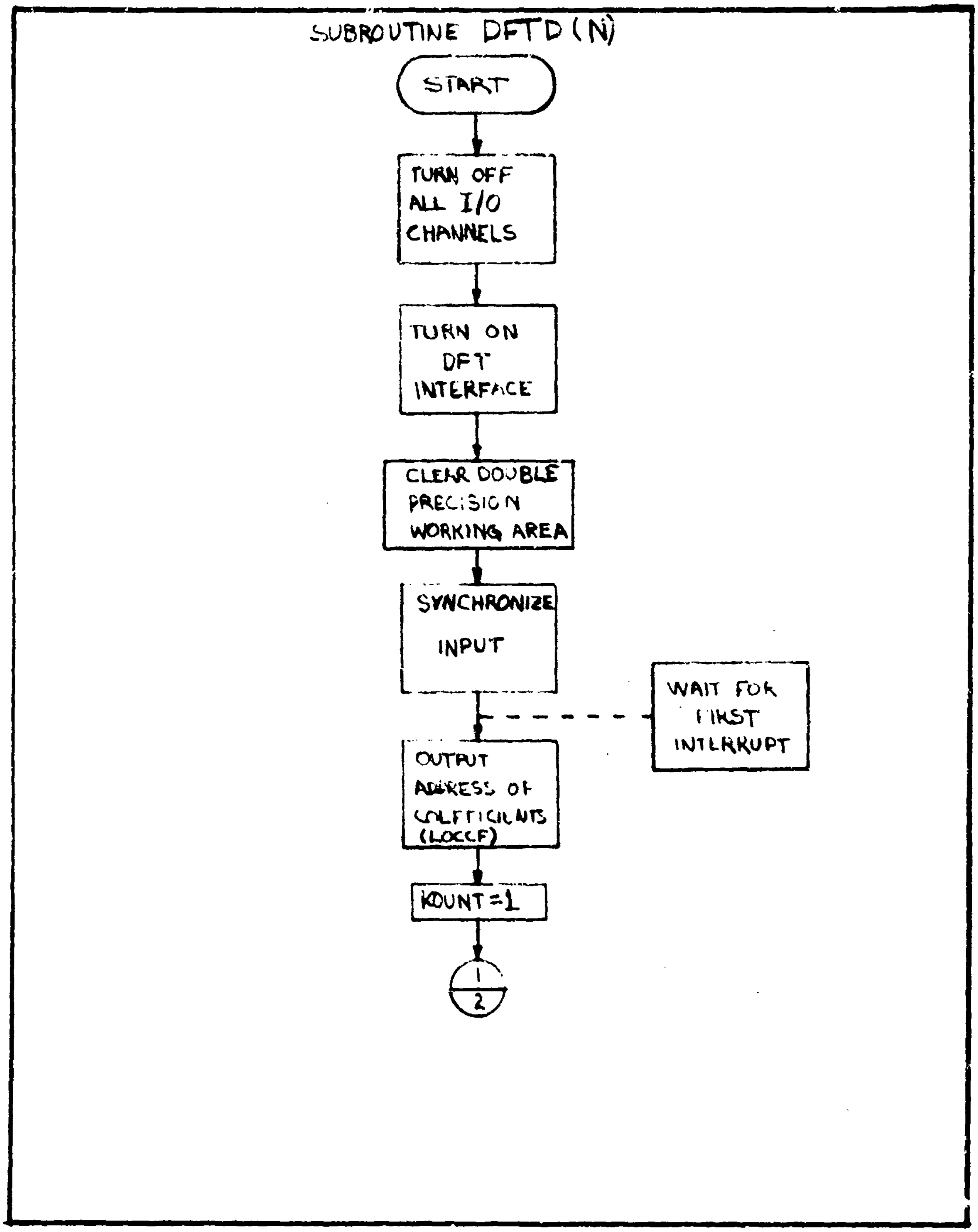

Figure 7 : SUBROUTINE DFTD **Page** 1 **of** 4

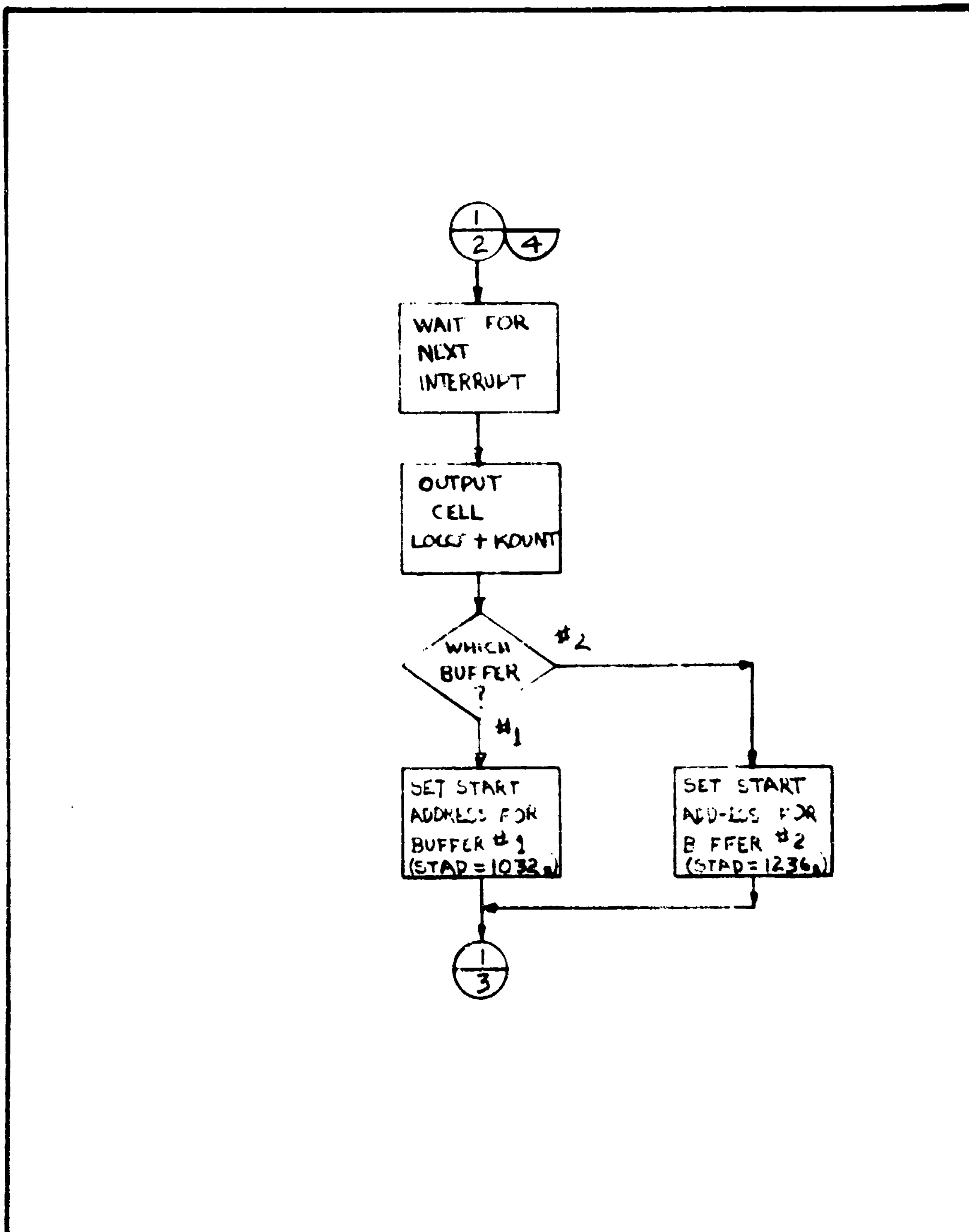

Figure 7 : SUBROUTINE OFTD **Page** 2 **of** 4

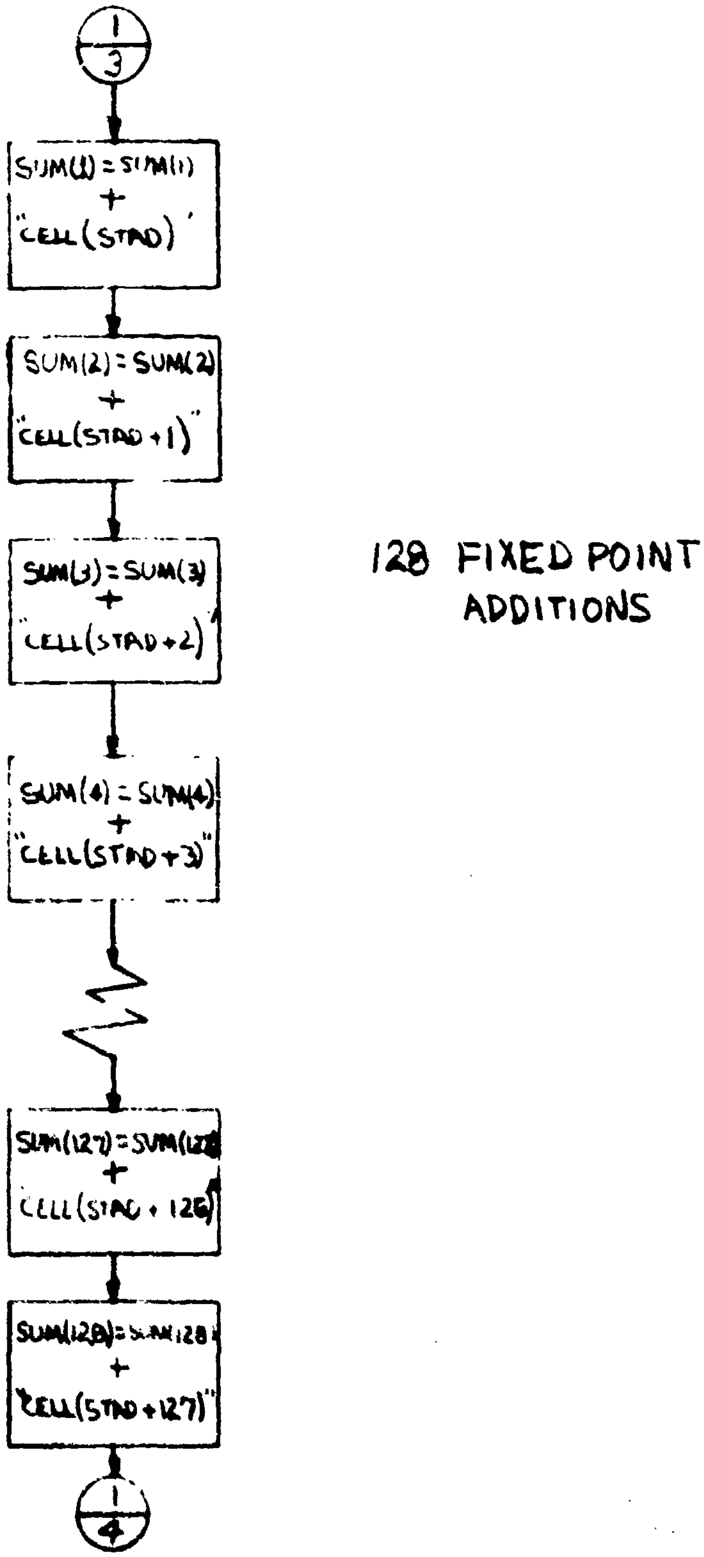

Figure 7 : SUBROUNTINE DFTD

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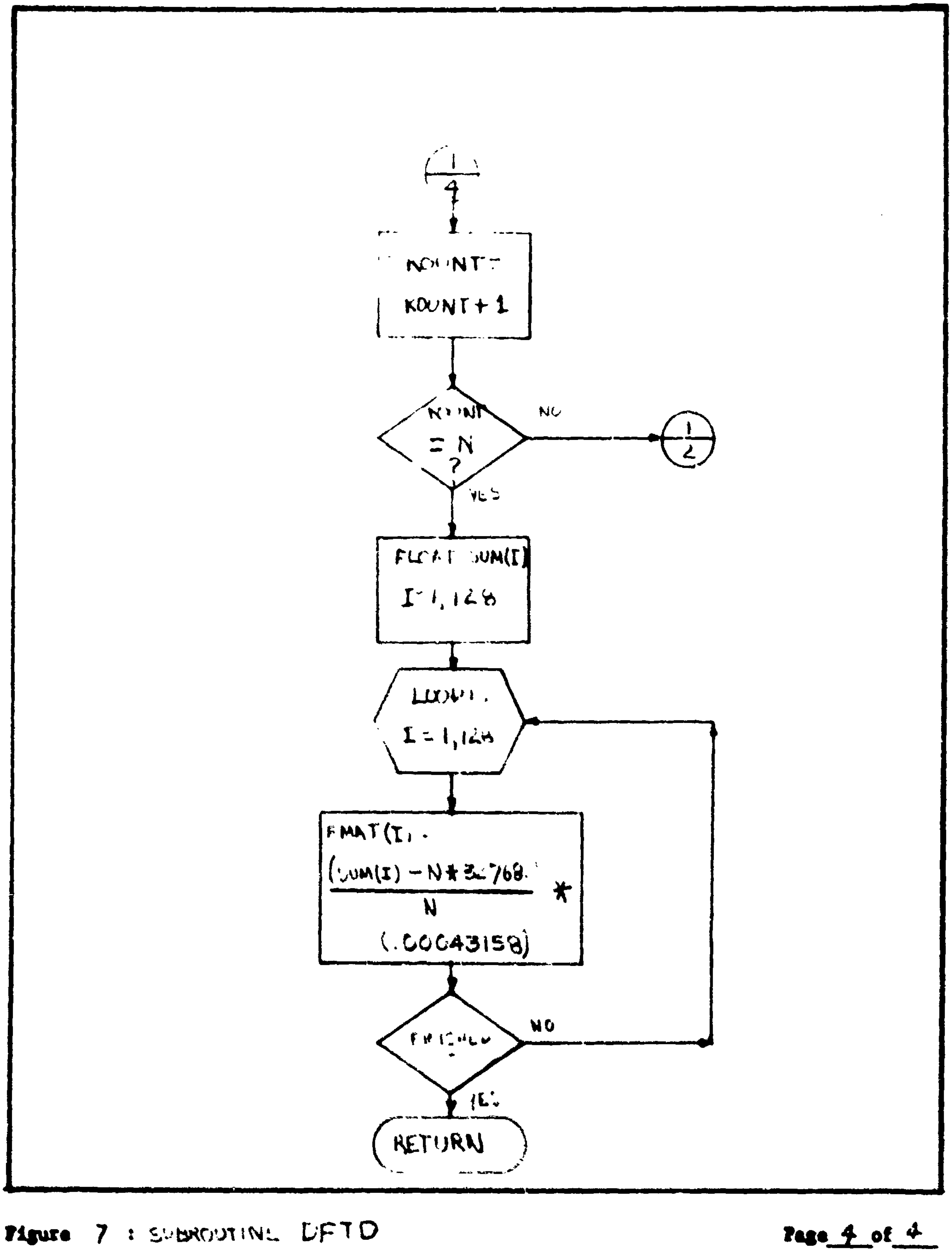

Figure 7 : SUBROUTINE DFTD

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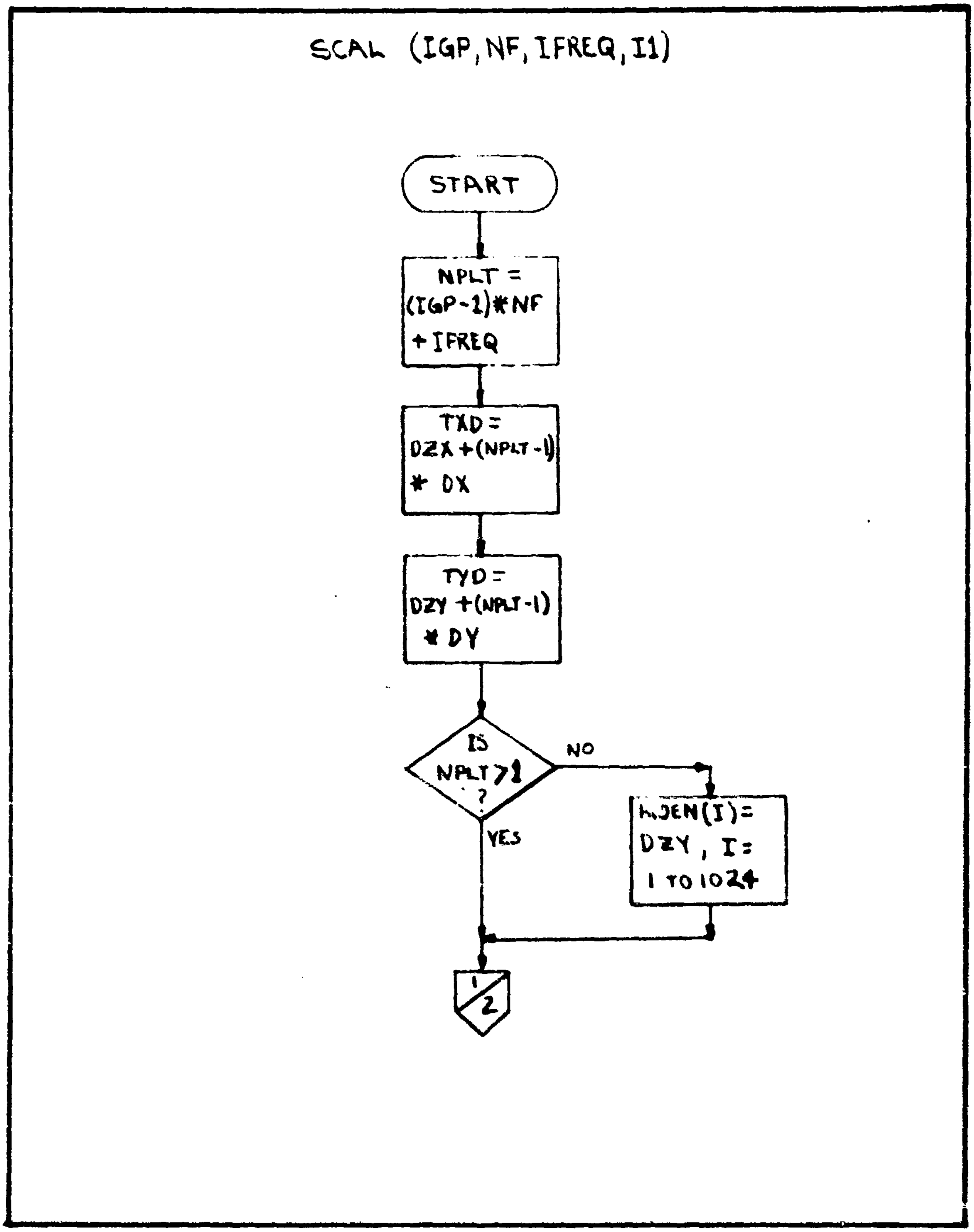

Figure 8 : SUBROUTINE SCAL

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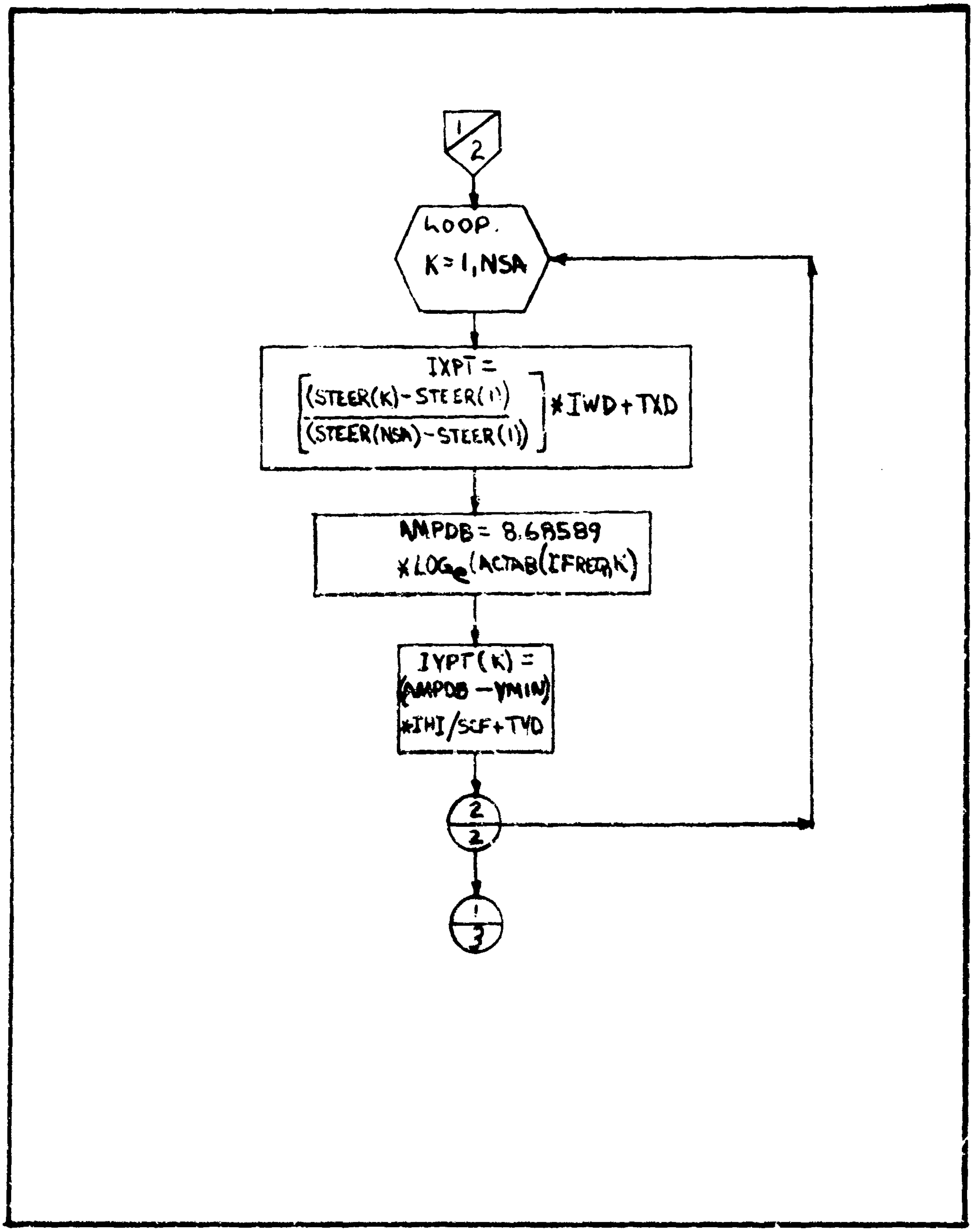

Figure 8 : SUBROUTINE SCAL

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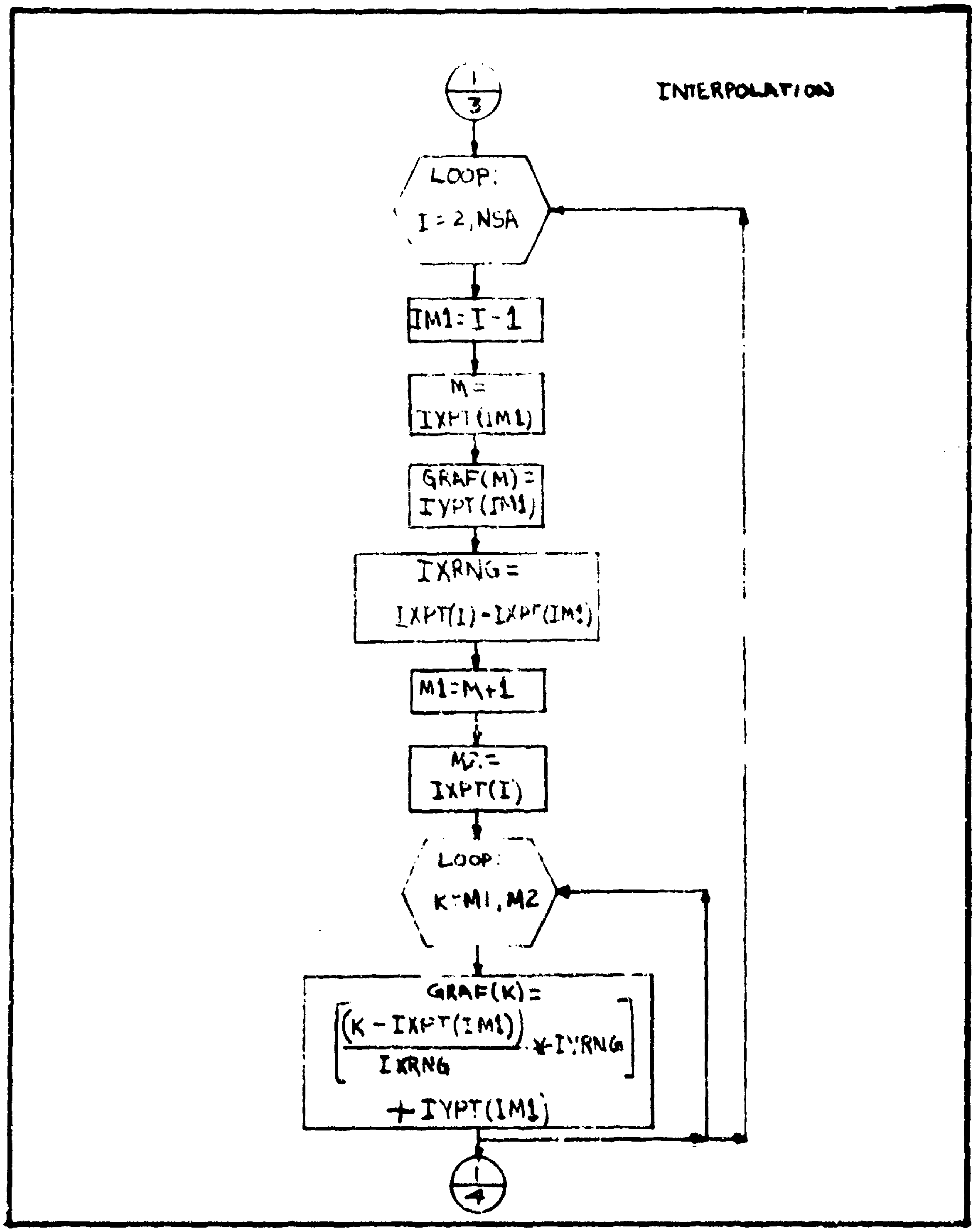

Figure 6 : SUBROUTINE SCAL

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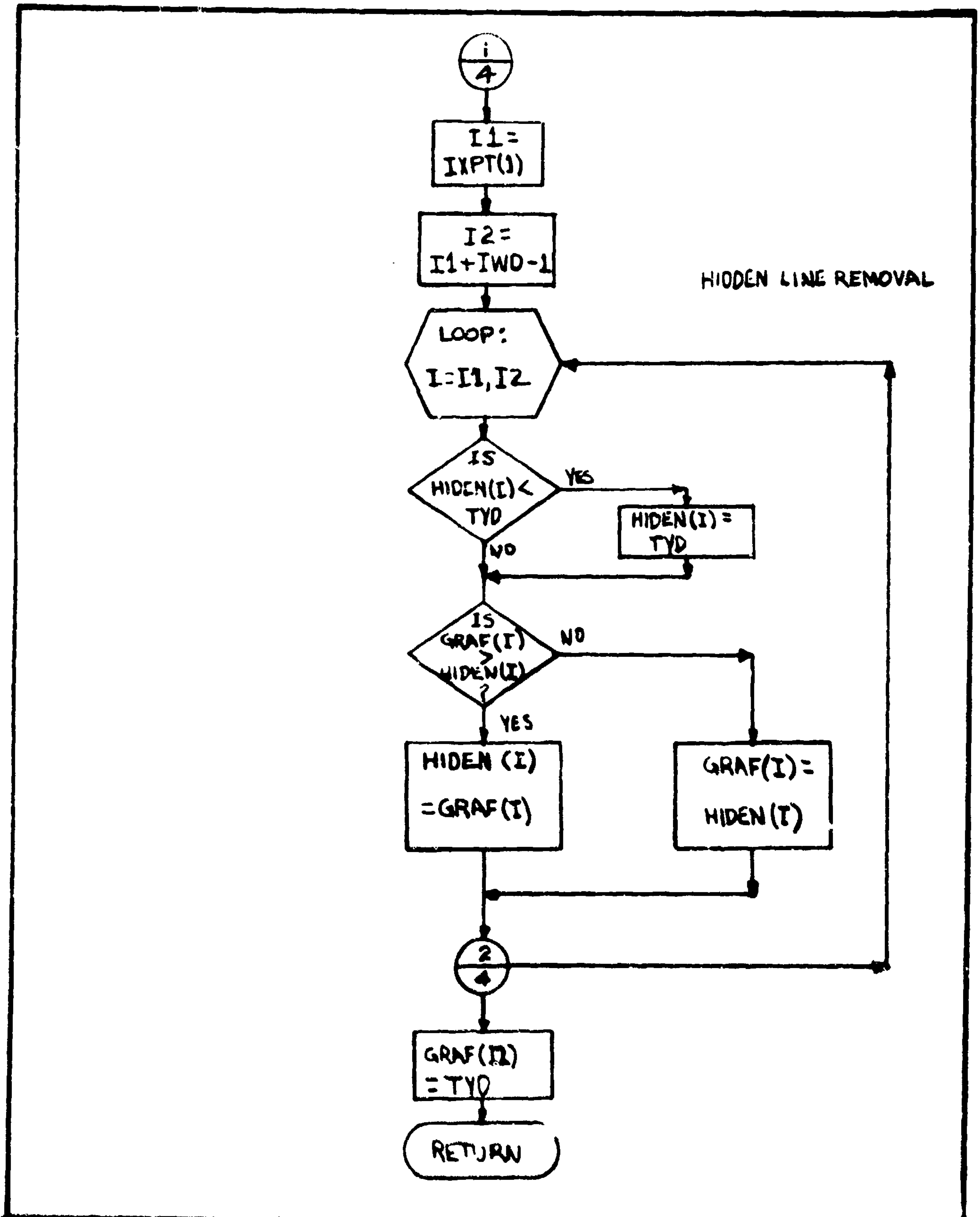

Figure 8 : SUBROUTINE SCAL

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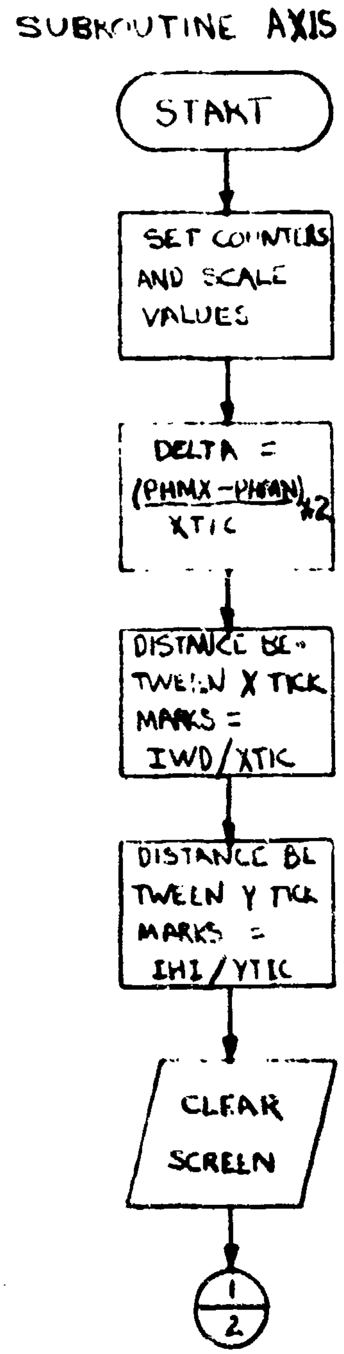

Figure 9 : SUBROUTINE AXIS

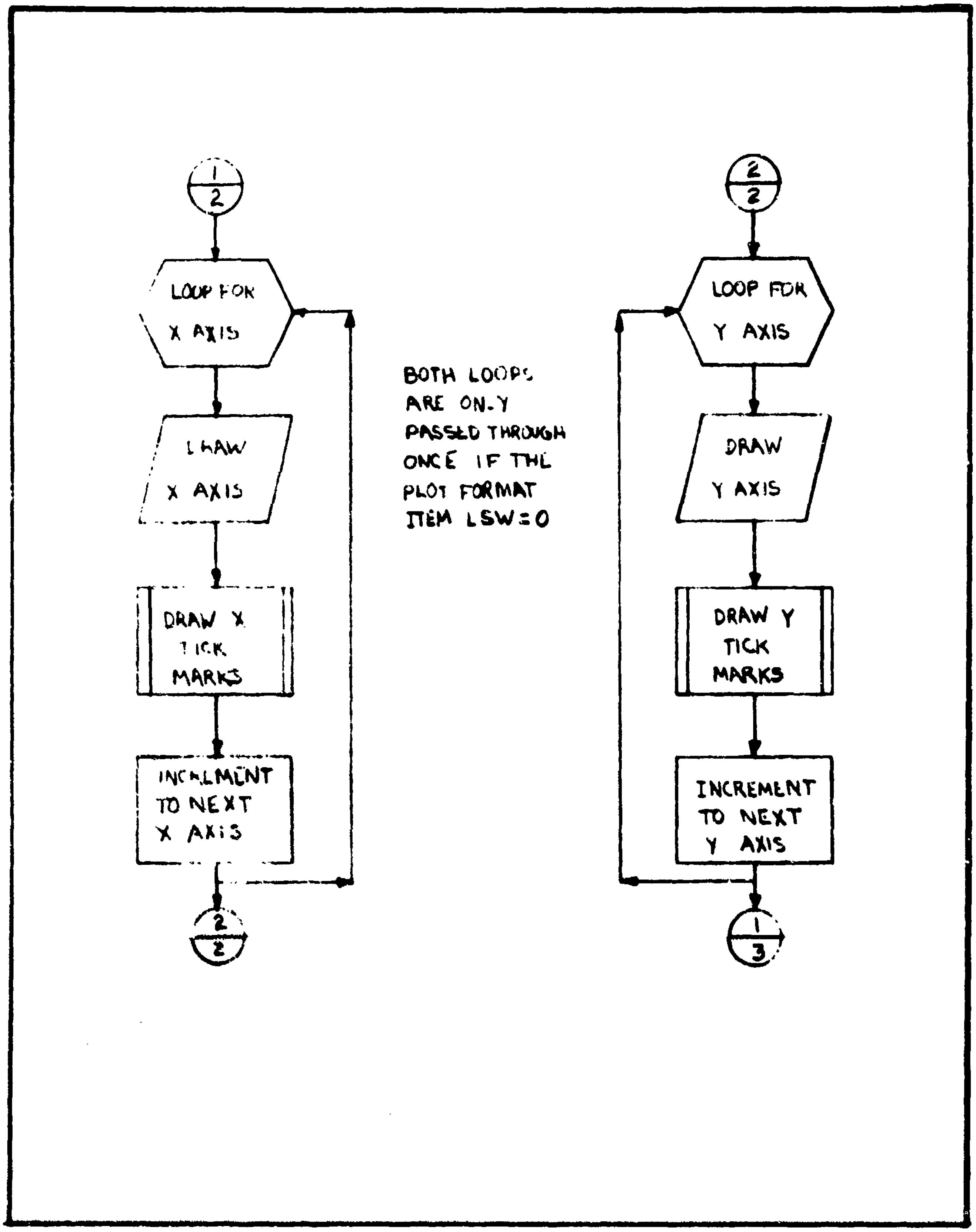

Figure 9 : SUBROUTINE AXIS   Page 2 of 3

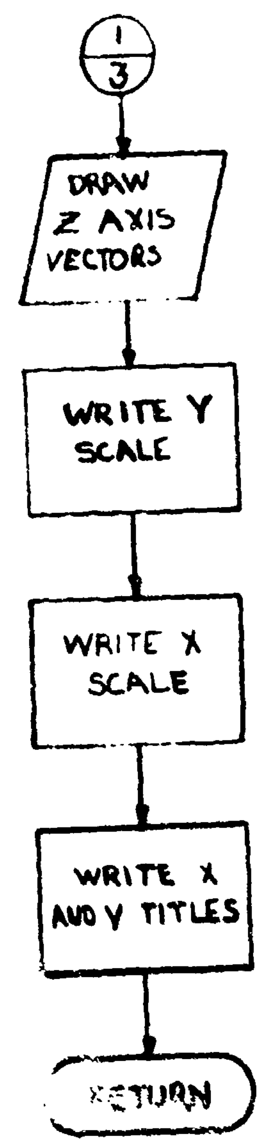

Figure 9 : SUBROUTINE AXIS

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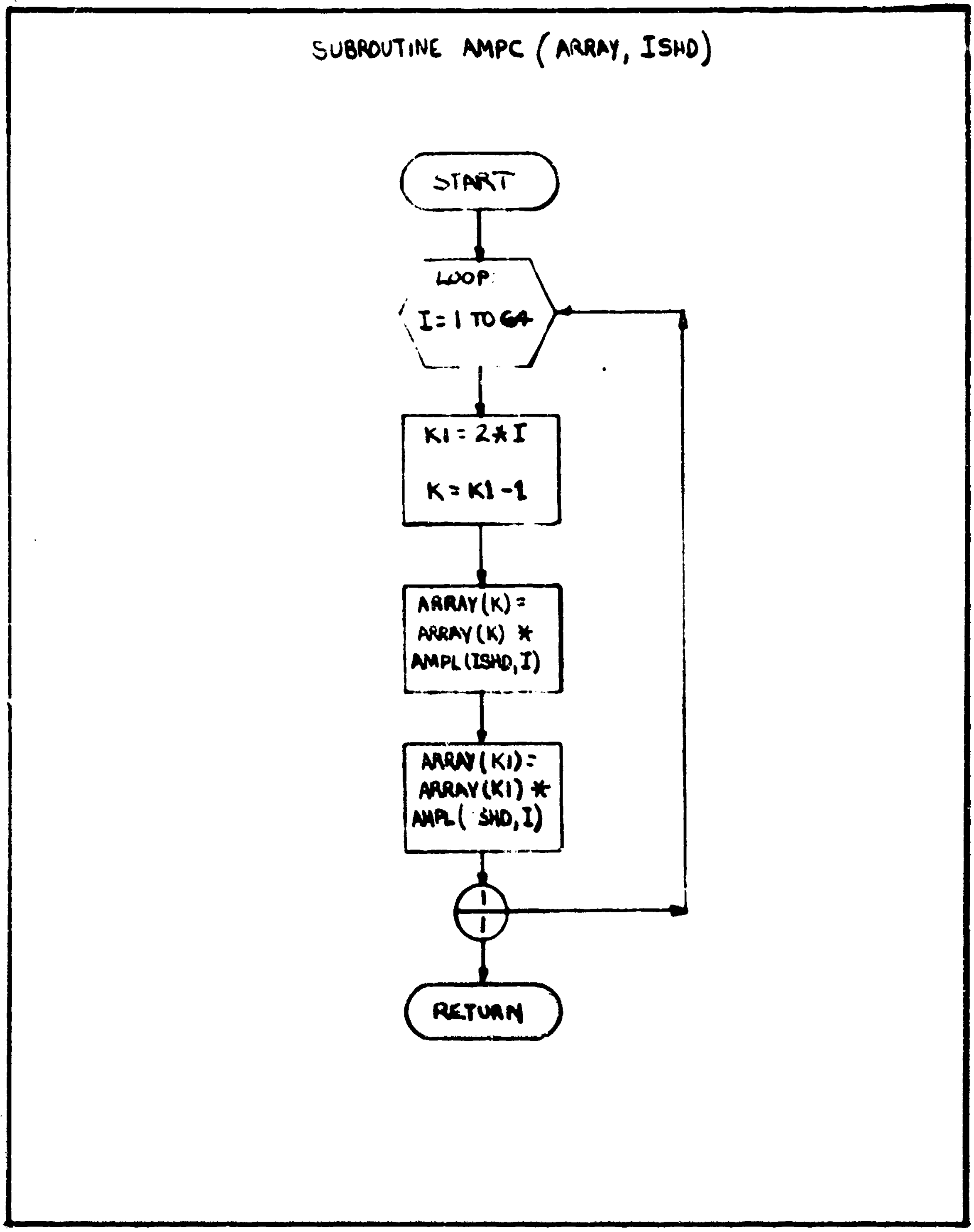

Figure 10 : SUBROUTINE AMPC

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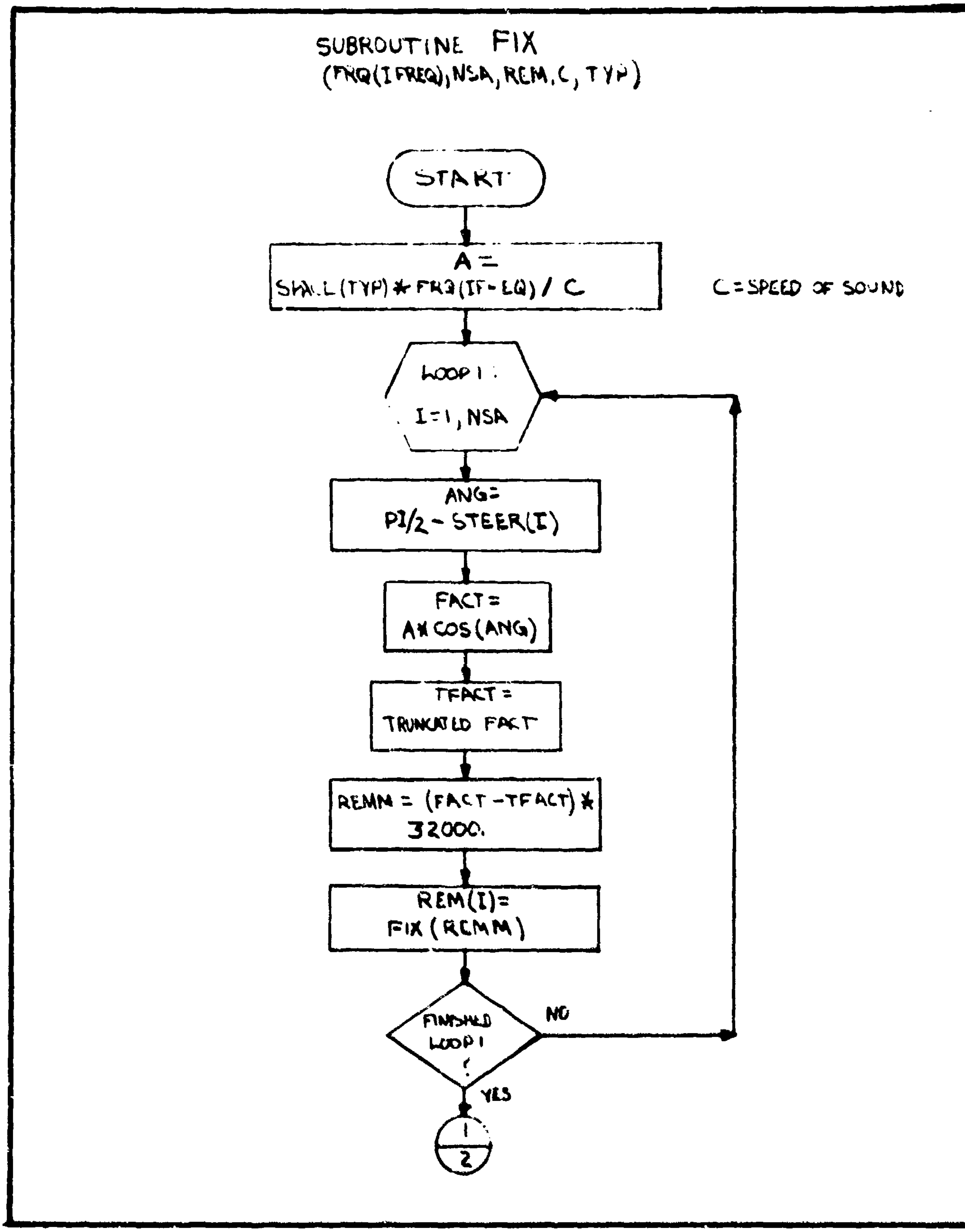

Figure 11 : SUBROUNTINE FIX

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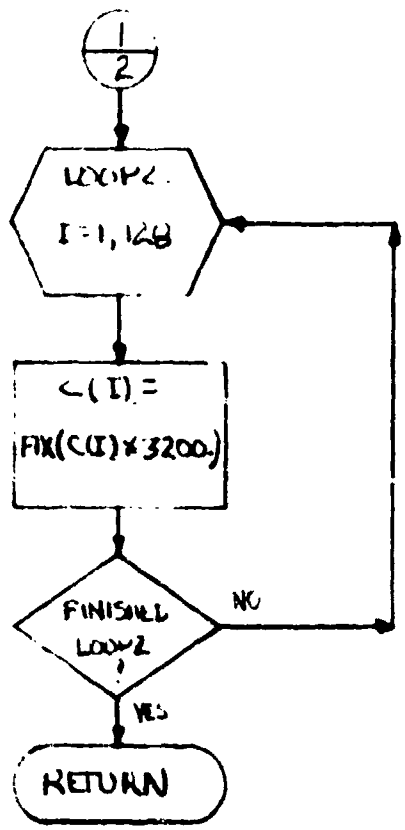

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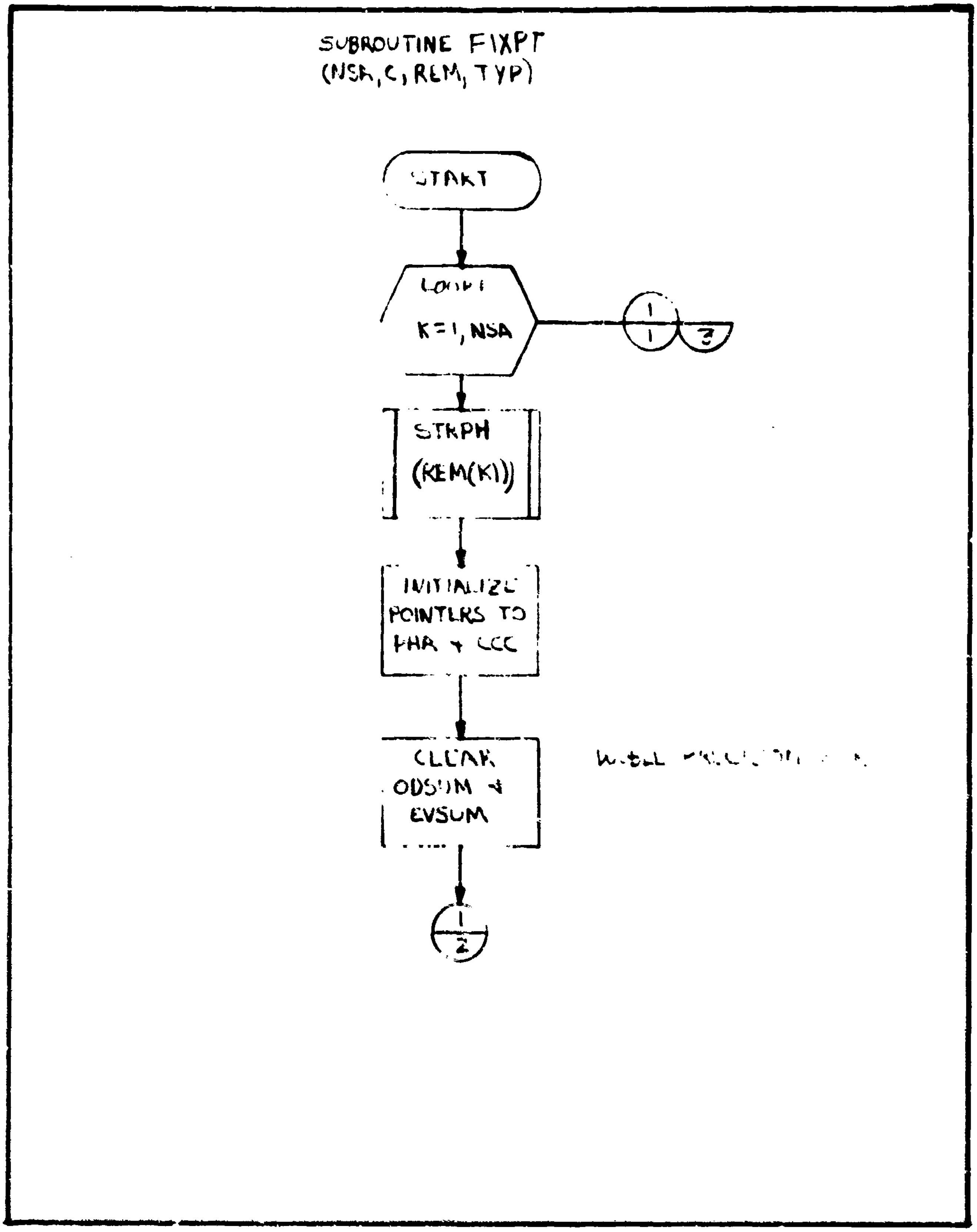

Figure 12 : SUBROUTINE FIXPT   Page 1 of 4

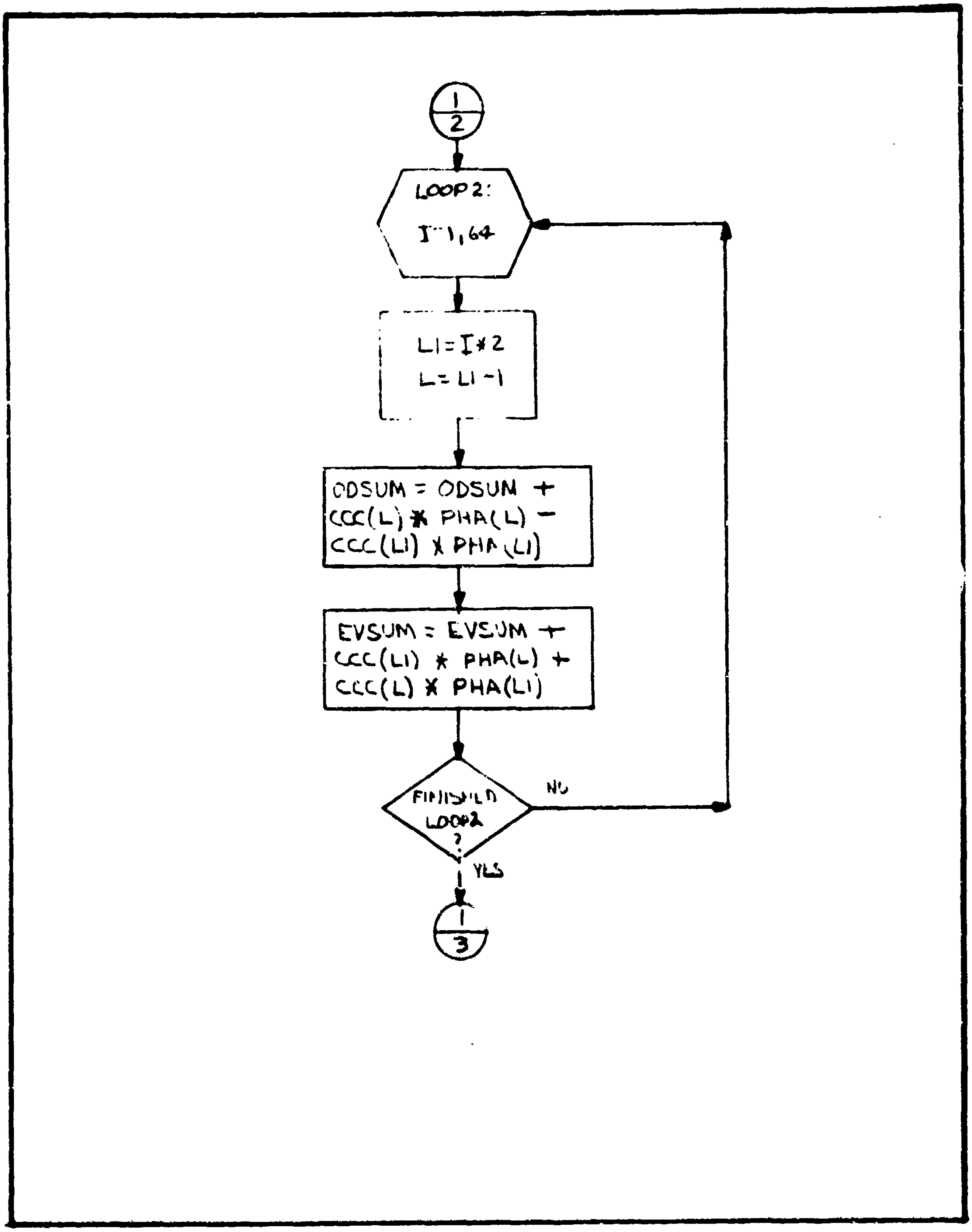

Figure 12 : SUBROUTINE FIXPT

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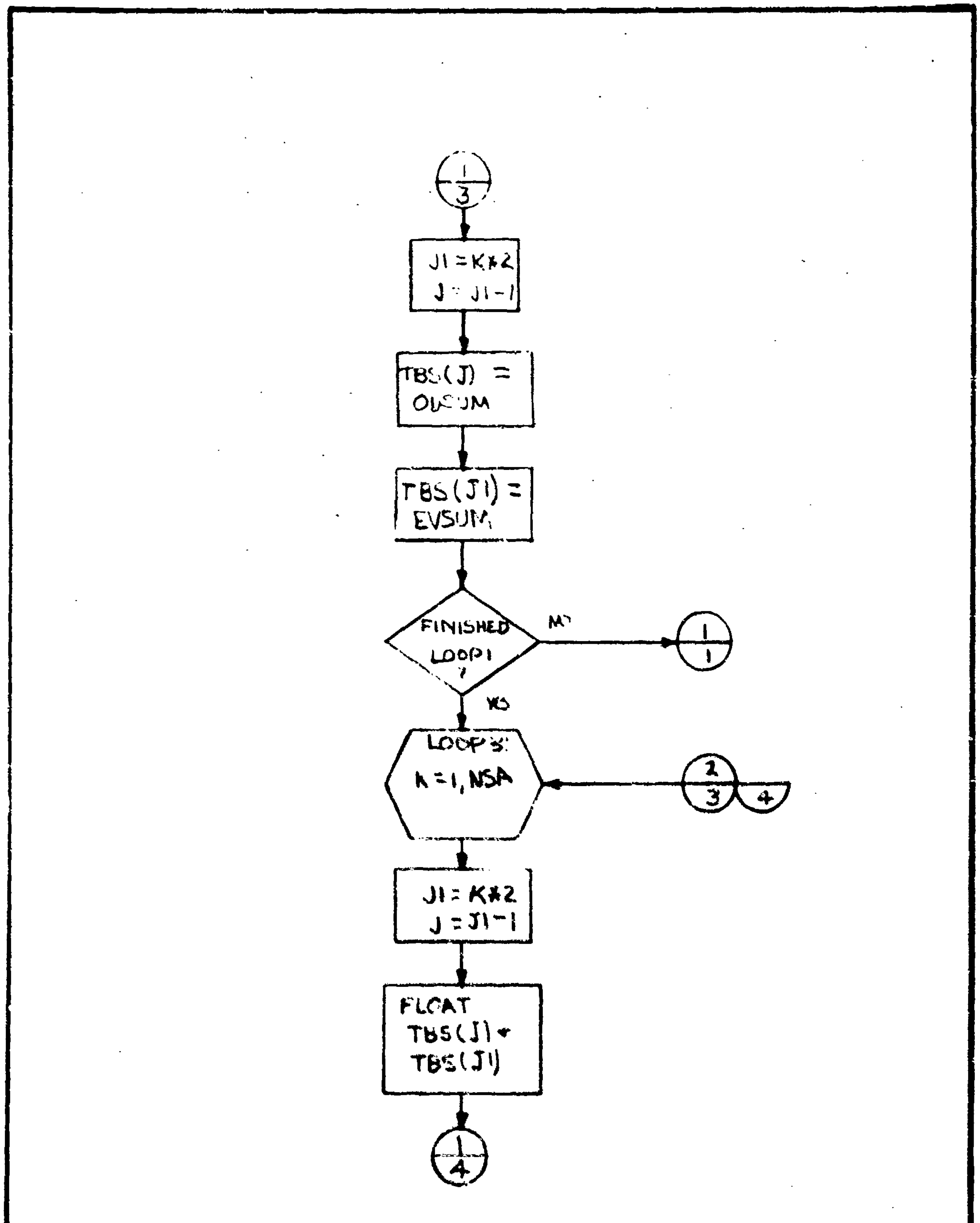

Figure 12 : SUBROUTINE FIXPT

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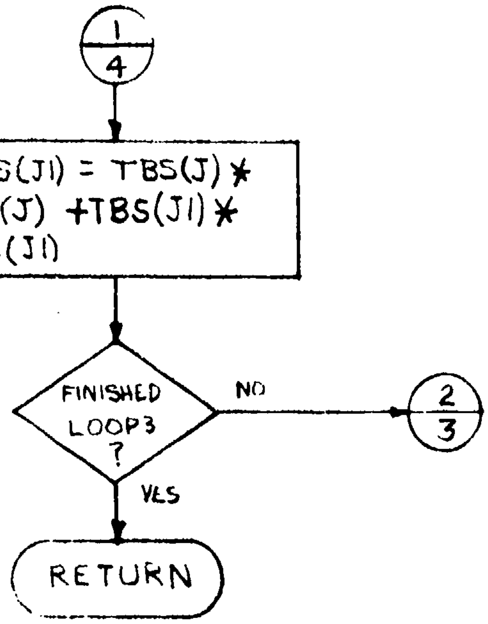

Figure 12 : SUBROUTINE FIXPT

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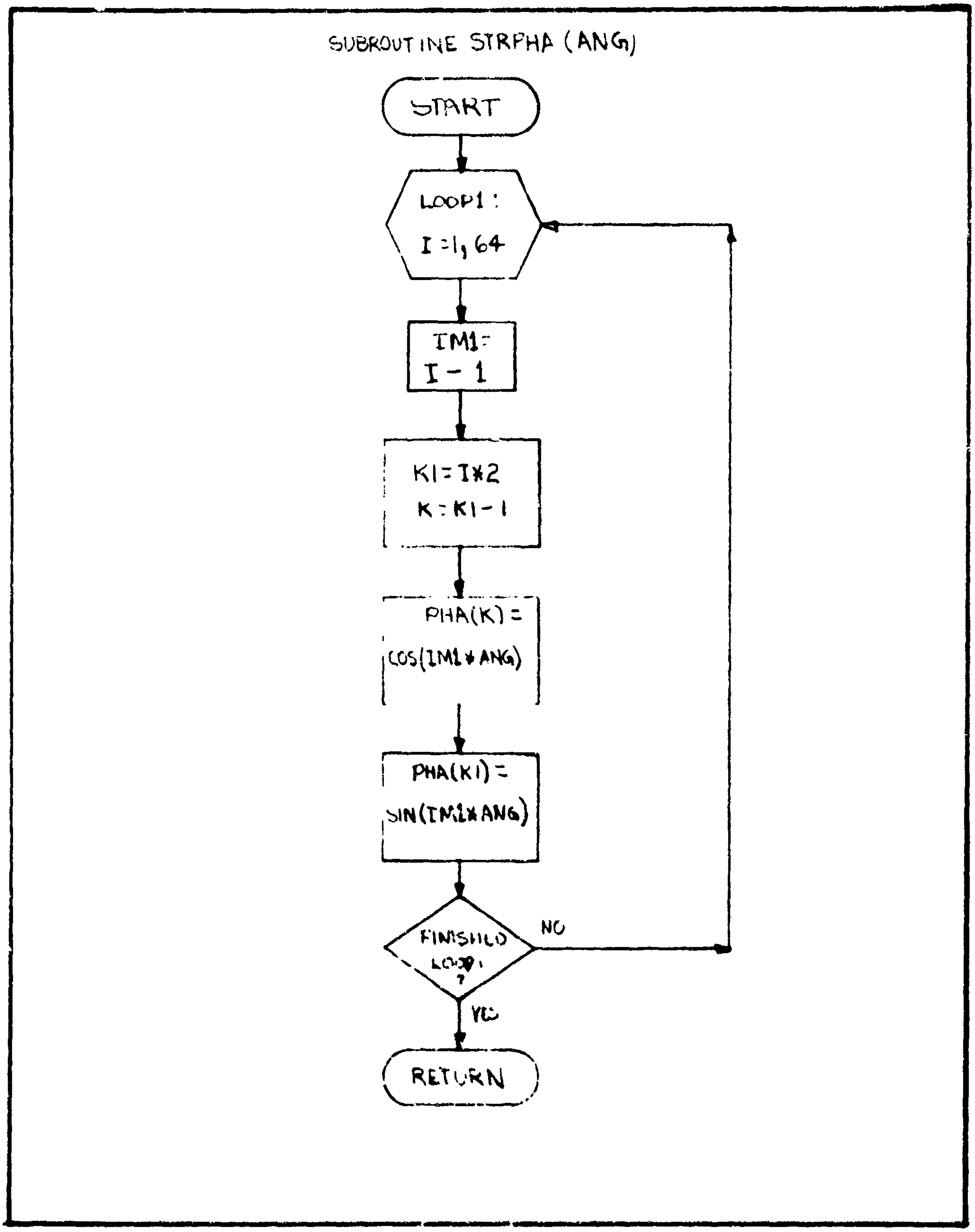

Figure 13 : SUBROUTINE STRPH

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Unavailable	Beam, J. P., et al.	LONG-RANGE ACOUSTIC PROPAGATION LOSS MEASUREMENTS OF PROJECT TRANSLANT I IN THE ATLANTIC OCEAN EAST OF BERMUDA	Naval Underwater Systems Center	740612	ADC001521	U
Unavailable	Cornyn, J. J., et al.	AMBIENT-NOISE PREDICTION. VOLUME 2. MODEL EVALUATION WITH IOMEDEX DATA	Naval Research Laboratory	740701	AD0530983	U
Unavailable	Unavailable	COHERENCE OF HARMONICALLY RELATED CW SIGNALS	Naval Underwater Systems Center	740722	ADB181912	U
Unavailable	Banchero, L. A., et al.	IOMEDEX SOUND VELOCITY ANALYSIS AND ENVIRONMENTAL DATA SUMMARY	Naval Oceanographic Office	740801	ADC000419	U
3810	Unavailable	CONSTRUCTION AND CALIBRATION OF USRD TYPE F58 VIBROSEIS MONITORING HYDROPHONES SERIALS 1 THROUGH 7	Naval Research Laboratory	741002	ND	U
ARL-TM-73-11; ARL-TM-73-12	Ellis, G. E., et al.	ARL PRELIMINARY DATA ANALYSIS FROM ACODAC SYSTEM; ANALYSIS OF THE BLAKE TEST ACODAC DATA	University of Texas, Applied Research Laboratories	741015	ADA001738; ND	U
Unavailable	Mitchell, S. K., et al.	QUALITY CONTROL ANALYSIS OF SUS PROCESSING FROM ACODAC DATA	University of Texas, Applied Research Laboratories	741015	ADB000283	U
Unavailable	Unavailable	MEDEX PROCESSING SYSTEM. VOLUME II. SOFTWARE	Bunker-Ramo Corp. Electronic Systems Division	741021	ADB000363	U
Unavailable	Spofford, C. W.	FACT MODEL. VOLUME I	Maury Center for Ocean Science	741101	ADA078581	U
Unavailable	Bucca, P. J., et al.	SOUND VELOCITY STRUCTURE OF THE LABRADOR SEA, IRMINGER SEA, AND BAFFIN BAY DURING THE NORLANT-72 EXERCISE	Naval Oceanographic Office	741101	ADC000461	U
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Unavailable	Baker, C. L., et al.	FACT MODEL. VOLUME II	Office of Naval Research	741201	ADA078539	U
ARL-TR-74-53	Anderson, A. L.	CHURCH ANCHOR EXPLOSIVE SOURCE (SUS) PROPAGATION MEASUREMENTS (U)	University of Texas, Applied Research Laboratories	741201	ADC002497; ND	U
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AESD-TN-75-01	Spofford, C. W.	ACOUSTIC AREA ASSESSMENT	Office of Naval Research	750201	ADA090109; ND	U